University of Belgrade

Faculty of Mechanical engineering

Course catalog

M.Sc. (graduate) academic studies

Belgrade
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MFB

aerospace engineering

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Aeroelasticity

ID: MSc-0645
teaching professor: Динуловић Р. Мирко
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: aerospace engineering

goals

1. introduction to modern aeroelasticity problems and their analysis and practical methods to solving aeroelasticity problems in real aircraft structures
2. introduction to experimental dynamic analysis of aircraft structures
3. introduction to dynamics of thin walled structures

learning outcomes

1. mastering basic theoretical knowledge related to aeroleasticty
2. application of theoretical knowledge to solve aeroelasticity problems on real aircraft structures

theoretical teaching

In the theoretical part of the course following topics are covered: Introduction to aeroelasticity. Types of aeroelastic phenomena on aircrafts and structures in general. Static, dynamic aeroelasticity. Differntial equations and solution methods. Galerkin’s method, collocation at the point, collocation at subdomain. Oscillations, types, mathematical models. Wing divergence, Command reversal, Flutter. Oscillations of continual distributed mass.

practical teaching

During practical part of the course covered topis in theoretical part are demonstrated in practice. Typical practical problmes are analyzed through numerical examples. Students are required to complete practical project work using computer modeling and analysis. All required material is available in the form of lecture notes, books and past exams and tests.

prerequisite

Mathematics, Resistance of materials

learning resources

Computing Laboratory for Theory of elasticity and Aeroelasticity

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 10

laboratory exercises: 0
calculation tasks: 5
seminar works: 0
project design: 10
consultations: 5
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 5
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 5
colloquium, with assessment: 0
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 20
laboratory exercises: 0
calculation tasks: 10
seminar works: 0
project design: 20
final exam: 40
requirements to take the exam (number of points): 40

references

An introduction to the theory of aeroelasticity, Y.C. Fung, Dover publication

Aircraft armement systems

ID: MSc-0344
teaching professor: Ступар Н. Слободан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: aerospace engineering

goals

The study of this course is to ensure adoption of procedures and methods for problem solving related to aircraft armament calculations. Students will be capable of independently study aircraft rocket, bomber and firearms armament elements in order to obtain maximum effectiveness for the given conditions of application for each of these types of aircraft weapons. Particular attention will be faced towards development trends of modern aircraft armament.

learning outcomes

By mastering of the course curriculum student obtains following subject-specific skills:

- thorough knowledge and understanding of different types of aircraft weapons and their application
- calculation of air weapons characteristics and possibility of their integration into the aircraft with the use of scientific methods and procedures
- linking basic knowledge in mathematics, programming, mechanics and fluid mechanics and their application in design and calculation of aviation weapons and its integration;

theoretical teaching

-Introduction to aircraft armament field
-Division and classification
-Historical development
-Development trends
-Aircraft bomber armament
-Determining the actual coordinates of the aim
-Aerodynamic integration of bombs, carriers and aircraft
-Underslung load influence on aircraft characteristics
-Aircraft underslung load removal calculations
-Trajectory stabilization
-Determination of forces and moments on the underslung loads
-Parachutes and braking devices
-Aircraft missile systems
-The basic components of missiles and their arrangement
-Structure calculations and structure types
-Slender bodies aerodynamic characteristics
-Aerodynamic interference
-Steering elements design features
-Stability derivatives
-Damping of the pitching and rolling
-Firearms
-Definition and division of firearms
-The basic components and mechanisms
-Determination of forces and loads

-Dynamics and shock in the automatic mechanisms, equipment and parts
-Existing solutions of integration
-Depreciation recoil force in accordance with the construction of aircraft
-Connections in aircraft-container system.

practical teaching

-Division and classification of aircraft armament
-Aircraft bomber armament, air bombs classification
-Aerodynamic bombs, carrier and aircraft integration
-Stabilization path
-Parachutes
-Aircraft missile armament
-Missile classification
-Design characteristics
-Aerodynamic schemes
-The basic components of missiles and their rearrangement
-Rocket structure and construction calculation
-Aerodynamic interference
-Steering elements design features
-Stability derivative
-Aircraft firearms
-Firearms definition and division
-The main components and mechanisms
-Determination of forces and loads
-Dynamics and shocks in the mechanisms
-Existing integration solutions
-Depreciation recoil force

prerequisite

There is no necessary requirement for attendance of Aircraft Armament.

learning resources

1. Jankovic S. Aerodinamika projektila, Faculty of Mechanical Engineering, Belgrade, 1979,КДА (in Serbian)
2. Additional materials (written handouts, problem setting, guidelines for problem solving), DVL

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 30
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0

discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 10
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 60
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 40
requirements to take the exam (number of points): 30

references

Aircraft control and systems

ID: MSc-0109
teaching professor: Јанковић М. Јован
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: aerospace engineering

goals

Subject task is to introduce students with integrated flight control computer systems, their functions, structures and principles. This have to enable students to enter into more detailed integration of aircraft systems and its components in aircraft control.

learning outcomes

By the subject student gets knowledges and understandings about existing aircraft integrated control computer systems. These knowledges enables understending of aircraft control systems if they are oriented to other aeronautical fields, or to further specialization in this aeria.

theoretical teaching

Functions and structure of integrated aircraft control computer systems. System components. Various type of aircraft control systems. Sensors, busses, processors. Displays. Actuators. Flight control systems. Autopilots. Stabilisators. Dynamic models of flight. Longitudinal and lateral dynamic models. Transfer functions. Autopilot synthesis. Autopilot structure. Short period aproximation. Gust model. Control comand model.

practical teaching

Practical teaching is related to prezenting samples, analysis and discusion with students in the fields previously treated theoretically. System components. Various type of aircraft control systems. Sensors, busses, processors. Displays. Actuators. Flight control systems. Autopilots. Stabilisators. Dynamic models of flight. Longitudinal and lateral dynamic models. Transfer functions. Autopilot synthesis. Autopilot structure. Short period aproximation. Gust model. Control comand model. Simulation model of short period longitudinal motion. Longitudinal dynamic model of F-14. Dynamic model of short period dynamics controler for F-14. Hydraulic dynamic model of horizontal stabilizator for F-14.

prerequisite

Students must have corresponding semestar in which this subject is teaching.

learning resources

Various written forms from teching.
Various books and papers.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 20
laboratory exercises: 0
calculation tasks: 0
seminar works: 10
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 5
check and assessment of projects: 0
colloquium, with assessment: 5
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 30
laboratory exercises: 0
calculation tasks: 0
seminar works: 30
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

Aircraft Design

ID: MSc-0136
teaching professor: Петровић И. Златко
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: project design
parent department: aerospace engineering

goals

Purpose of the subject is to introduce students to submit concept of the aircraft. Process include analysis of existing similar airplanes and assessment of their good and weak points. To select optimum concept. To define basic geometric parameters of an aircraft. To select configuration, propulsion system, specific load and specific thrust/power. To calculate loads, performances and stability of the airplane.

learning outcomes

After attending all lectures and recitations and after completion of projects students will be able to analyze, to specify and to develop aircraft concept according to required purpose and performances. Completion of project assumes passage through whole process of conceptual aircraft design. For selected segment of aircraft student should complete preliminary design, and for certain parts detail design of these parts should be included in the student project.

theoretical teaching

Definition of aircraft purpose and mission. Statistical analysis and definition of trends. Basic geometric parameters of the airplane. Definition or selection of propulsion system. Integration of propulsion, equipments and avionics. Landing gear definition. Determination of aircraft loads and basic dimensioning of aircraft elements. Production technology, selection of standard elements, selection of materials. Properties of materials used in aircraft design. Static stability of the airplane. Dynamic flight properties, flaying qualities. Basic performances, special performances, takeoff and landing. Cost of the project.

practical teaching

Purpose to illustrate lectures on practical examples, and to answer to student needs to complete homework project. After completion students presents project to professors and students of the department. Grading depends on quality of the presented project, activity of the student during school year, and on the quality of presentation. During exercise student use software CAD tool CATIA and exercise basic commands in part, assembly, sheet metal, and generative surface design modules.

prerequisite

Defined by curricula of study program.

learning resources

1. Handouts
2. Lecture slides
3. SimLab laboratory
4. Software tool CATIA

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 0
laboratory exercises: 15
calculation tasks: 0
seminar works: 0
project design: 5
consultations: 10
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 10
colloquium, with assessment: 0
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 15
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 55
final exam: 30
requirements to take the exam (number of points): 25

references

D. Raymer, Aircraft Design: A Conceptual Approach, AIAA Education Series,
A. K. Kundu, Aircraft Desing, Cambridge University Press, Cambridge, 2010
Roskam, Aircraft Design 1 - 8, Ottawa, Kansas, USA
Corke, Aircraft Design
D. Howe, Aircraft Conceptual Design Synthesis, London, UK, 2000

Aircraft Maintenance

ID: MSc-0154
teaching professor: Рашуо П. Бошко
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: aerospace engineering

goals

In the course of aircraft maintenance students will get basic knowledge of contemporary theory and practice of maintenance and overhaul of civil and military aircraft. Also, one part of the course will be devoted to the study of maintainability, reliability, combat survivability analysis, as the basic structural characteristics of the system, which are defined in the early stages of design and development of modern aircraft.

learning outcomes

Completed the planned curriculum introduces students to the procedures of creative thinking and decision making in the field of maintenance of aircraft and acquire sufficient theoretical and practical knowledge that is able to participate in the team that designed the aircraft or maintain or revitalize, sublimating sizes such as reliability, maintainability, fighting tenacity and tolerance to damage aircraft in the event of forced landing.

theoretical teaching

Introduction. General Settings in the maintenance of aircraft, maintenance of aircraft. Security and reliability in air traffic. Maintenance concept. Maintenance activities, levels of maintenance. Maintenance of aircraft in the airline, line and base maintenance, Quantitative indicators of maintainability, Mathematical models in maintenance of aircraft, Economic reasonable life expectancy of equipment and systems, the required number of spare parts, the optimal number of checks, minimum total costs, reliability, availability, and time to failure to periodically maintained systems. Determination of the interval of preventive replacement of components and systems, prediction of maintainability, Aeronautical Safeguarding providing aircraft maintenance technology aircraft and the control and identification of state aircraft.

practical teaching

Activity and levels of maintenance, line and base maintenance of commercial aircraft, the probability distributions under consideration convenience of maintenance and reparability, optimization of maintenance costs, maintainability function, function reparability, index of maintainability, security maintenance indicator, indicator of human labor. Factors the availability of elements (equipment): Self (internal) availability, achieved (reached) the availability, application availability, achieved availability. Development of computational tasks in the contents taught, activities in the prediction of maintainability, maintainability of aircraft structures, making computational tasks in the traversed material, Diagnostics - Nondestructive testing methods, modern concept of Aeronautical Safeguarding securing aircraft, combat survivability, vulnerability of aircraft and Consultation.

prerequisite

No special requirements

learning resources

Books, B. Dhillon, MECHANICAL RELIABILITY: THEORY, MODELS AND APPLICATIONS, AIAA Education Series, 1988, include necessary material for lectures, exercises, assignments, projects and term papers. Require additional materials (handouts, setting assignments, term papers, etc..) Are given at the web site or reproduced on paper. Large-scale electronic materials can be made available to students in direct contact.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 10
laboratory exercises: 0
calculation tasks: 0
seminar works: 10
project design: 0
consultations: 10
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 10
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 15
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 55
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

B. Dhillon, MECHANICAL RELIABILITY: THEORY, MODELS AND APPLICATIONS, AIAA Education Series, 1988.
F. Delp, R. Bent and J. McKinley, AIRCRAFT MAINTENANCE AND REPAIR, McGraw-Hill Co., 1987.
R. E. Ball, THE FUNDAMENTALS OF AIRCRAFT COMBAT SURVIVABILITY ANALYSIS AND DESIGN, AIAA Education Series, 2003
Hongzhou Wang and Hoang Pham, Reliability and Optimal Maintenance, Springer-Verlag, London, 2006

Aircraft Performance

ID: MSc-0348
teaching professor: Рашуо П. Бошко
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: aerospace engineering

goals

Introduce students to the complex movement of aircraft in atmospheric flight. Students will learning the performance of aircraft, ie the movement of aircraft center of gravity in space under the action of forces. Under the terms of reference that encompasses and integrates the entire field contents taught, students will be able to work independently and with the use of modern software packages, such as: Matlab, Mathcad, Excel, etc.. fully master the budget performance aircraft in the airspace.

learning outcomes

Completed the planned curriculum students obtain sufficient theoretical knowledge that is able to be creatively self-performance capabilities to define the modern aircraft and all restrictions of flight options that resulting from it. In this course students will receive full sublimation and verification of previously acquired knowledge and skills that they get into the aviation module from aerodynamic case.

theoretical teaching

Introduction,Performance Characteristics, Absolute Performance Characteristics, Functional Performance Characteristics, The Approach, Equations of Motion, General Information, The Energy Approach, Fundamental Performance Equation, Stalling Speed, Maximum Velocity and Ceiling, General Considerations, Drag and Drag Polar, Flight Envelope: Vmax, Vmin, Power Required and Power Available, Turboprop Engines, Gliding Flight, Glide Angle and Sinking Speed, Glide Range and Endurance, Climbing Flight, Rate of Climb, Climb Angle, Time to Climb, Shallow Flight Paths, Load Factor, Partial Power and Excess Power, Range and Endurance, Reciprocating Engine, Jet Aircraft, Range Integration Method, Flight Speeds, Effect of Energy Change on Range, Endurance, Reciprocating Engines, Turbojets, Endurance Integration Method, Additional Range and Endurance Topics, The Effect of Wind, Some Range and Endurance Comparisons, Nonsteady Flight in the Vertical Plane, Take-off and Landing, Take-off Analysis, Ground Run, Rotation Distance, Transition Distance, Take-off Time, Factors Influencing the Take-off, Landing, Landing Phases, Landing Run, The Approach Distance, The Flare Distance, Accelerating Flight, Maneuvering Flight, Turns in Vertical Plane: Pull-Ups or Push-Overs, V−n Diagram, Turning Flight in Horizontal Plane, Maximum Sustained Turning Performance, Maximum Load Factor, Minimum Turn Radius, Maximum Turning Rate, The Maneuvering Diagram, Spiral Flight, Constraints Tied to Performance Equation, Energy Methods.

practical teaching

Propulsion, propeller selection, performance power plant, Computation of basic aircraft performance, Making computational tasks in the traversed material, Computation of special aircraft performance, range and budget autonomy flight, Making computational tasks in the traversed material, calculation of movement in the vertical plane: The budget planning. Polar speed planning. Budget diving. The marginal rate of diving. Budget out of the dive. Coefficient load the recovery. Calculation of a sudden pitch and jumping out of airplanes. Calculation of dynamic peak summer. Calculation of the loop calculation turning aircraft turnaround from sliding. properly coordinated turn. Turn limits performance. Combat turn. Extreme caution. Coated flight and spin. Maneuvering flight envelope, extreme caution and consultation.

prerequisite

Required: Aerodynamic design

learning resources

Books, Maido Saarlas, Aircraft Performance, John Wiley & Sons, Inc,Hoboken, New Jersey, 2007, include necessary material for lectures, exercises, assignments, projects and term papers. Require additional materials (handouts, setting assignments, term papers, etc..) Are given at the web site or reproduced on paper. Large-scale electronic materials can be made available to students in direct contact.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 15
laboratory exercises: 0
calculation tasks: 5
seminar works: 0
project design: 0
consultations: 10
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 10
colloquium, with assessment: 0
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 15
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 10
seminar works: 0
project design: 45
final exam: 30
requirements to take the exam (number of points): 35

references

Maido Saarlas, Aircraft Performance, John Wiley & Sons, Inc,Hoboken, New Jersey, 2007

Aircraft propulsion

ID: MSc-0120
teaching professor: Јојић Ж. Бранислав
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: aerospace engineering

goals

Course objective is to introduce students to the types and principles of functioning of basic aircraft power elements, as well as their characteristics and domains of use. Furthermore, the relation between the type of the aircraft and propulsion system is pointed out, so that each mission can be realized in an optimal way according to the desired goals and constraints.

learning outcomes

By mastering this course, a student acquires abilities to perform analysis and synthesis of the whole system that consists of the aircraft and its power elements. A student gains knowledge on structures of the various types of aircraft engines and components they are made of. Based on the acquired knowledge on the engine performances, a student is able to form an opinion on the quality of usually used engines and will acquire knowledge necessary for further self-improvement.

theoretical teaching

Thermodynamic cycles and thrust. Propulsion efficiency and basic engine performances. Propulsion system and elements necessary for its implementation. Ideal ramjet and turbojet engines. Ideal turbojet engine with after-burning chamber. Ideal double-flow turbojet engines: with separate and joint air currents. Real elements of propulsion circuits: inlet and nozzle. Real elements of propulsion circuits: compressor and turbine. Real elements of propulsion circuits: mixer, basic and after-burning chamber. Graphs of power and thrust engines. Starting the engine. Engine performances: velocity, height and damp performance. Domains of use of certain engine types. Current problems, trend and perspectives of aircraft propulsion.

practical teaching

Practical work consists of presentation of examples and their analysis and discussion of the previously presented theory. Thermodynamic cycles and thrust. Propulsion efficiency and basic engine performances. Propulsion system and elements necessary for its implementation. Ideal ramjet and turbojet engines. Ideal turbojet engine with after-burning chamber. Ideal double-flow turbojet engines: with separate and joint air currents. Real elements of propulsion circuits: inlet and nozzle. Real elements of propulsion circuits: compressor and turbine. Real elements of propulsion circuits: mixer, basic and after-burning chamber. Graphs of power and thrust engines. Starting the engine. Engine performances: velocity, height and damp performance. Domains of use of certain engine types. Current problems, trend and perspectives of aircraft propulsion.

prerequisite

The condition of attending the course is to successfully complete all required courses that are prior to this one.

learning resources

Written lectures.
Written exercises.
Charts of flow functions. Standard atmosphere chart. Charts of thermodynamic gas properties.
Internet

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 30
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 10
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 20
test/colloquium: 30
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 50
requirements to take the exam (number of points): 50

references

Algorithams and Data Structures

ID: MSc-0471
teaching professor: Петровић И. Златко
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: project design
parent department: aerospace engineering

goals

1. Algorithams and their complexity. 2. Representation of real and integer number sets in computer. Problems in their representation and their accuracy. 3. Lists, trees, graphs, stacks, queue and other data structures. 4. Searching algorithms. Iterations and recursion.

learning outcomes

Usage of derived data structures and corresponding algorithms in modeling complex promlems in mechanical engineering. 2. Selection of fastest, the most efficient, and the most accurate algorithms in problem solutions. 3. Selection of algorithams from iterative or recursive approach. 4. Error in complex calculations and its control.

theoretical teaching

Thematically divided into four pieces: 1. Representation of data in computer, correctness of representation. Elementary and derived data structures, data modelling. Basic operations on data structures. 2. Algorithams and procedures in data modelling and data processing. 3. Algorithms for ordering, sorting, searching and presentation of primitive and derived data structures. 4. Stacks, queues as a basic data types in computer real time usage. Banker's algorithm and Dining philospher problem.

practical teaching

It is organized in form of laboratory exercises and as a project homework. Laboratory works: 1) Programing of examples in compund adata structures. 2) Data structures for batch and real time processing. 3) Algorithms for compund data processing. Diekstra's algorithm, binary sorting and searching, heuristic algorithms. 4) Project assumes developement of a group of modules used to process data of the specified problem. Project is selected to illustrate data processing in mechanical engineering.

prerequisite

Knowledge of C and Java programming language is assumed.

learning resources

[1] Gnu C

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 0
laboratory exercises: 15
calculation tasks: 0
seminar works: 0
project design: 15
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 4
colloquium, with assessment: 0
test, with assessment: 6
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 5
laboratory exercises: 25
calculation tasks: 0
seminar works: 0
project design: 40
final exam: 30
requirements to take the exam (number of points): 35

references

Applied Aerodynamics

ID: MSc-0275
teaching professor: Стефановић А. Зоран
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: aerospace engineering

goals

The objective for course is to develop an understanding of low-speed aerodynamics and an introduction to compressible flows. The course covers concepts in incompressible airfoil theory, including symmetric and cambered airfoils using analytical and numerical approaches. The course also covers incompressible wing theory, including down wash, lifting-line theory, elliptic wings, general twisted wings, application of fundamentals to the design of a wing to meet given performance criteria.

learning outcomes

After passing the subject the students are expected to understand and explain various aspects of the link between the body shape and its aerodynamic characteristics. In addition, it is expected that students recognize the use of opportunities acquired knowledge in aerodynamics, to other areas of technics.

theoretical teaching

In the theoretical part of Course the following topics are analyzed(lessons). Two-dimensional problems - airfoil characteristics: the method of singularities, thin airfoil theory, method of droplets, panel methods, empirical methods and the determination of aerodynamic loads. Three-dimensional problems: vortex wing models, the theory of vortex line, surface vortex method, panel method, approximate load calculation methods in the wings. Analysis of wing - body combination (aerodynamic constructive schemes). Aerodynamic characteristics of complete aircraft. Role of CFD in the analysis and determination of aerodynamic characteristics.

practical teaching

In the practical part of the Course professor demonstrate the numerical examples in various areas. Practical work of students is realized through a virtual laboratory available 24 hours (program MOODLE). In the workshop students are available to the professor's written notes, lectures, assignments and tests for practice. Practical training includes the preparation of terms of reference. Homework project each student performs individually.

prerequisite

None. Students that on bachelour studies did not pass any of a group of aerodynamic courses are referred to the additional notes of professors.

learning resources

This course has a virtual classroom on the Internet. At the first lecture students are enrolled and trained for work (Moodle software). In the workshop approach is performed with the lectures and exercises, guidelines for project design, internet resources, etc..

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 10
laboratory exercises: 0
calculation tasks: 5
seminar works: 0
project design: 5
consultations: 10
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 5
colloquium, with assessment: 0
test, with assessment: 5
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 15
test/colloquium: 10
laboratory exercises: 0
calculation tasks: 0
seminar works: 20
project design: 25
final exam: 30
requirements to take the exam (number of points): 25

references

J. Bertin, M. Smith, AERODYNAMICS FOR ENGINEERS, Prentice Hall, 1989.
2. J. Katz, A. Plotkin, LOW-SPEED AERODYNAMICS - FROM WING THEORY TO PANEL METHODS, McGraw-Hill, 1991.

Avionics

ID: MSc-0311
teaching professor: Петровић Б. Небојша
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: aerospace engineering

goals

Objectives of the course are to introduce students to aviation electronic equipment and systems, their functions, structures and basic principles. The subject should provide students a detailed a detailed view of the latest trends in avionics technology and development.

learning outcomes

Successful completion of course students acquire the ability to understand the existing solutions aviation electronic equipment and systems.The student acquires knowledge about the structures of various types of avionics equipment and systems.
The knowledge that allow students to opt for other aviation issues to understand the electronic aviation equipment and systems,and for those who want to specialize in these issues are fundamental to the acquired knowledge for further work.

theoretical teaching

Avionics elements,AS 15531/MIL-STD-1553B, ARINC 429.Commercial standard digital bus. Head-Up displays, Head-mounted displays.Flight deck design.Batteries, Characteristcs, Types.Avionics functions.Fly By Wire-Electrical flight controls, system architecture,
modes of the system,pitch control, roll control, yaw control, failure detection. Navigation and Communications,sattelite communications and navigation systems,ATC. Flight management systems,automatic direction finding,distance measuring
equipment,TACAN.Visualization.Traffic collision an Avoidance system.Instruments landing system.Certification of civil avionics.Software,Ada,RTCA DO-178B/EUROCAE ED-12B. Implementation,B-777,A330/340,MD-11,F-22

practical teaching

Practical work includes the presentation of examples, analysis and discussion with students in areas that were previously presented theory.
Avionics elements,AS 15531/MIL-STD-1553B, ARINC 429.Commercial standard digital bus. Head-Up displays, Head-mounted displays.Flight deck design.Batteries, Characteristcs, Types.Avionics functions.Fly By Wire-Electrical flight controls, system architecture,
modes of the system,pitch control, roll control, yaw control, failure detection. Navigation and Communications,sattelite communications and navigation systems,ATC. Flight management systems,automatic direction finding,distance measuring
equipment,TACAN.Visualization.Traffic collision an Avoidance system.Instruments landing system.Certification of civil avionics.Software,Ada,RTCA DO-178B/EUROCAE ED-12B. Implementation,B-777,A330/340,MD-11,F-22

prerequisite

The condition of attending the course is student enrollment in the semester in which this subject is taught.

learning resources

Written sources from the lecture.
Written sources from the auditory exercises.
Civil Avionics Systems,I.Moir and A.Seabridge
Intelligent piezo actuators, N. Petrovic

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 20
laboratory exercises: 0
calculation tasks: 0
seminar works: 10
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 5
check and assessment of projects: 0
colloquium, with assessment: 5
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 30
laboratory exercises: 0
calculation tasks: 0
seminar works: 30
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

The Avionics Handbook, Cary R. Spitzer

Bionics in Design

ID: MSc-0159
teaching professor: Рашуо П. Бошко
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: aerospace engineering

goals

Introducing students to the process and the procedure of synthesis (create) a combination of mechanical systems engineering design (design) and industrial and bionic design. Besides, the goal of this course is to develop creative skills of students in the design of machines. Understanding the methodology and procedures to create innovative mechanical system through the phase of designing, selection of parameters, dimensions and shape of machine parts, alignment features (functional and aesthetic) with the environment, living and working environment.

learning outcomes

The student is introduced to the procedure of abstract thinking and creative idea generation, the development methodology of the new principal, conceptual, based on bionic solutions. Dressed in designing machine parts and assemblies based on bionic principles, functional, technological, aesthetic, ergonomic, and others. Trained to implement budgets for the mutual adjustment of parameters of machine parts with the limitations, the development of forms and sizes.

theoretical teaching

History and Development bionic system. Experience in engineering: flying, navigation, civil engineering, architecture, and military construction. Inclusion bionic aspects in the design process and construction of mechanical systems. Mathematical principles of bionic system. Fibonacci sequence. Fibonacci spiral. "Gold" section (the relationship) and "Golden" angle. The influence of the golden ratio in engineering design. The concept of fractals and fractal geometry. Cantor set. Euclid’s natural forms. The effects of scale, form and similarity in nature and their impact on the development of modern machine design and systems. Energy efficiency of natural systems as models in the design of modern engineering structures, the experience of flight, navigation, energy, process engineering, military technology and others. Natural (bionic) building materials. Modern composite materials. Thermoplastic and thermosetting materials in engineering. "Smart" and functional materials in engineering structures and modern design.

practical teaching

Influences Leonardo da Vinci, Sir George Cayley, Ota Liliental, Gustav Ajfel, Raul Fransea and Graf von Zeppelin. Bio-strategy application process in fulfilling the spirit of laws rules of biological evolution, which should translate into an acceptable technical solution. Ten basic principles of natural structures. Implementation bionic humanoid proportions and impact on the ergonomic design. Some typical relations (numbers) that characterize the specific effects of similarity and scaling in nature. Bionic Design - views and role models. Wood, vegetable fiber, animal,: wool, silk, spider web, etc.. Natural resins. Artificial resins - matrix (binder) materials: Epoxy, Polyester, Vinyl ester, phenolic, polyimide, Bizmaleimid et al. Cellular materials, intelligent optical fiber. Electrical and magnetic reostatic. Semiconductor spinotronic. Magnetic materials. DNA nano-products.

prerequisite

No special requirements

learning resources

Books, Werner Nachtigall, Biologisches Design, Springer-Verlag Berlin Heidelberg 2005, include necessary material for lectures, exercises, assignments, projects and term papers. Require additional materials (handouts, setting assignments, term papers, etc..) Are given at the web site or reproduced on paper. Large-scale electronic materials can be made available to students in direct contact.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 10
laboratory exercises: 0
calculation tasks: 0
seminar works: 10
project design: 0
consultations: 10
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 10
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 15
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 55
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

Werner Nachtigall, Biologisches Design, Springer-Verlag Berlin Heidelberg 2005
Mircea Gh.Negoita, Sorin Hintea, Bio-InspiredTechnologies for the Hardware of Adaptive Systems, Springer-Verlag, Heidelberg, 2009
Ranjan Vepa, Biomimetic Robotics - mechanisms and control, CAMBRIDGE UNIVERSITY PRESS, Cambridge, 2009

Composite Structures

ID: MSc-0639
teaching professor: Динуловић Р. Мирко
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: aerospace engineering

goals

1. introduction to modern approach in stress analysis of composite material structures on aircraft, it's application to practical problems solutions as well as experimental methods applied to structural verifification of composite structures.
2.Introduction to specifics of thin walled structures and application of composite materials for these structures.
3.Introduction to computer simualtion and stress analysis of composite structures on aircrafts.

learning outcomes

1. mastering basic theoretical knowledge of structural analysis.
2. Application of theoretical principles to solution of practical problems
3. Understanding basic aircraft design principles
4. Understanding modern approach and methodology in design and stress-strain analysis of aircraft structures

theoretical teaching

Basic Definitions. Polymer Matrix and fiber characteristics. Prepregs. Fabrication processes. Autoclave polymerization. Characteristics of composite materials. Elastic stres-strain behavor of composite materials modeling. Plane stress. Principal stresses, principal deformations. Temperatre deformations. Deformations in respect to humidity. Failure Criteria applicable to composite media. Kirchoff and Midlin plate theories. Effective mechanical characteristics of laminates. Composite Beams. Interlaminar stresses. Composite buckling. Delamination, structural analysis of composte material constructuctions using finite element method.

practical teaching

In the practical part of the course, stress-strain theory applicable to composite media is demonstrated. Real practical problems are analyzed. Practical work is carried out using computers and finite element analysis software for composite materials structures. Students are provided with all necessary materials in the form of lecture notes, books and past exam and test papers.

prerequisite

Recommendation: Theory of elasticity, Strucural analysis of aircraft structures

learning resources

Course notes in electronic form, media materials, computer simulation models available after class, internet resources.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 10
laboratory exercises: 0
calculation tasks: 5
seminar works: 0
project design: 10
consultations: 5
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 5
colloquium, with assessment: 0
test, with assessment: 5
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 20
laboratory exercises: 0
calculation tasks: 10
seminar works: 0
project design: 20
final exam: 40
requirements to take the exam (number of points): 40

references

Engineering Mechanics of Composite Materials, D.Ishaii

Computational Aerodynamics

ID: MSc-0179
teaching professor: Петровић И. Златко
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: project design
parent department: aerospace engineering

goals

The goal of the course is to train students in modeling flow problems. After attending the course, finishing all exercises and giving the final presentation, students should be able to recognize the type of the problem, formulate necessary boundary and initial conditions, choose an appropriate discretization scheme and write a program for calculating flow inside or around simpler geometric shapes, such as a nozzle or an airfoil.

learning outcomes

By successfully adopting the program of the course, a student: acquires theoretical knowledge sufficient to recognize the type of the problem as well as the type and number of additional conditions necessary to completely and uniquely define the problem that is being simulated; recognizes basic approximation schemes of the typical problems; masters the principles and foundations of programming related to simulations of continuum; observes the structure of the simulation software that consists of pre-processing, simulation and visualization.

theoretical teaching

Derivation of the transport equation and its application to the basic laws of the fluid flow. Finite difference and finite volumes approximations of the partial differential equations. Basics of the generation of computational grids and their classifications. Transformation of the Navier-Stokes equations in general curvilinear coordinate systems. Metrics calculation and simplification of the boundary layer equations and parabolic Navier-Stokes equations. Computation of the Navier-Stokes equations for thin viscous layers. Approximation, boundary and initial conditions formulation, computation algorithm of direct numerical simulations. Compressible inviscid flow presented by an approximation of the Euler equation. Calculation of the transformation metrics for general curvilinear coordinate systems. Basics of turbulent flows modeling.

practical teaching

Practical training accompanies materials presented during theoretical lectures. In the beginning, students are registered and they familiarize with working in Linux operating system. After that, illustrative examples are completely presented starting with the problem formulation, presentation of the appropriate equations and their approximation, stability and convergence studies, code and reading of the necessary input data, finishing with presenting solutions graphically. Students solve their homework independently and present it to their colleagues.

prerequisite

Defined by the curriculum of the study program/module.

learning resources

1. KPN
2. KLR
3. MPI software

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 0
laboratory exercises: 20
calculation tasks: 0
seminar works: 0
project design: 5
consultations: 5
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 10
colloquium, with assessment: 0
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 15
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 55
final exam: 30
requirements to take the exam (number of points): 25

references

Computational Aerodynamics

ID: MSc-0577
teaching professor: Ступар Н. Слободан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: project design
parent department: aerospace engineering

goals

The goal of the course is to train students in modeling of flow problems. After attending the course, finishing all exercises and giving the final presentation, students should be able to recognize the type of the problem, formulate necessary boundary and initial conditions, choose an appropriate discretization scheme and write a program for calculating flow inside or around simpler geometric shapes, such as a nozzle or an airfoil.

learning outcomes

By successfully adopting the program of the course, a student:
-acquires theoretical knowledge sufficient to recognize the type of the problem as well as the type and number of additional conditions necessary to completely and uniquely define the problem that is being simulated;
-recognizes basic approximation schemes of the typical problems;
-masters the principles and foundations of programming related to simulations of continuum;
-observes the structure of the simulation software that consists of pre-processing, simulation and visualization.

theoretical teaching

Derivation of the transport equation and its application to the basic laws of the fluid flow. Finite difference and finite volumes approximations of the partial differential equations. Basics of the generation of computational grids and their classifications. Transformation of the Navier-Stokes equations in general curvilinear coordinate systems. Metrics calculation and simplification of the boundary layer equations and parabolic Navier-Stokes equations. Computation of the Navier-Stokes equations for thin viscous layers. Approximation, boundary and initial conditions formulation, computation algorithm of direct numerical simulations. Compressible inviscid flow presented by an approximation of the Euler equation. Calculation of the transformation metrics for general curvilinear coordinate systems. Basics of turbulent flows modeling.

practical teaching

Practical training accompanies materials presented during theoretical lectures. In the beginning, students are registered and they familiarize with working in Linux operating system. After that, illustrative ex famples are completely presented starting with the problem formulation, presentation of the appropriate equations and their approximation, stability and convergence studies, code and reading of the necessary input data, finishing with presenting solutions graphically. Students solve their homework independently and present it to their colleagues.

prerequisite

Defined by the curriculum of the study program/module.

learning resources

1. Petrović Z. Stupar S., Computer design, Faculty of Mechanical Engineering, 1992, KPN(in serbian)
2. 452, Computer Laboratory SimLab, ICT / CAH / KLR
3. FORTRAN, Computer Laboratory SimLab, ICT / PPO
4. MPI software

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 0
laboratory exercises: 20
calculation tasks: 0
seminar works: 0
project design: 5
consultations: 5
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 10
colloquium, with assessment: 0
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 15
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 55
final exam: 30
requirements to take the exam (number of points): 25

references

Flight Dynamics

ID: MSc-0186
teaching professor: Рашуо П. Бошко
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: aerospace engineering

goals

Introduce students to the dynamics of flight, ie. movement of aircraft in atmospheric flight. In this course students will studying the stability and maneuverability of aircraft, ie. movement of aircraft around the center of gravity. Under the terms of reference that encompasses and integrates the entire field contents taught, students will be capable of using modern software packages, such as: Matlab, Mathcad, etc.. fully master the calculation of stability and controllability of aircraft in the airspace.

learning outcomes

Completed the planned curriculum students obtain a sufficient theoretical knowledge that is able to be creatively independent state to define static and dynamic stability and maneuverability of modern aircraft and all restrictions of flight options that resulting from it. In this course students will receive full sublimation and verification of previously acquired knowledge and skills that they get into the aviation module from aerodynamic case.

theoretical teaching

Introduction to stability and control, Aims of study, First thoughts on stability, Choice of axes, Static and dynamic stability, Approximate treatment of response to gust, The natural time scale, Simple speed stability, Controls, Flap type controls, Balancing of flap type controls, Spoilers, Elementary treatment of pitching motion, Modelling an aircraft in slow pitching motion, Centre of pressure and aerodynamic centre, The pitching moment equation of the complete aircraft, Tailplane contribution to the pitching moment equation, The pitching moment equation, 'stick fixed', Trim, Trim, 'stick fixed', Trim, 'stick free', Trim near the ground, Static stability, Static stability, 'stick fixed, Static stability, 'stick free', Actions required to change speed, Stick movement and force to change speed, Manoeuvre stability, The pullout manoeuvre, Manoeuvre stability, 'stick fixed', Manoeuvre stability, 'stick free', The centre of gravity range and airworthiness considerations, Canard aircraft, Effects of springs or weights in the control circuit, Lateral static stability and control, Simple lateral aerodynamics, Aileron and rudder controls, Sideslip, Effect of rate of yaw, Trimmed lateral manoeuvres, The correctly banked turn, Steady straight sideslip, Minimum control speeds, Static stability, Revision and extension of dynamics, Some simple aircraft motions, Pure rolling, Pitching oscillation, The phugoid oscillation, Dynamics using moving axes, Equations of motion for a system of particles, Equations of motion for a rigid body, Moving frames of reference, Equations of motion of a rigid body referred to body fixed axes, Equations of motion of a rigid aircraft, Relations between the rates of change of angles, Development of the equations, Components of the weight, Small perturbations, Stability derivatives.

practical teaching

The criteria of stability and controllability of aircraft movements, calculating the contribution of individual components of aircraft longitudinal stability and overall kept the command, Rear center of gravity of the aircraft, Calculation of the longitudinal management of airplanes, Making computational tasks in the traversed material, The Stability Calculation of longitudinal static to put the command, calculation of forces on the stick in the stationary flight, Making computational tasks in the traversed material, calculation of the longitudinal static stability in maneuvering flight, Computation of longitudinal static stability in maneuvering flight with 'stick free', Derivatives and parameters in the equations of motion of aircraft, solution of equation of motion for the free command, Consultation.

prerequisite

Required: Aircraft Performance

learning resources

Books, J. B. Russell, Performance and Stability of Aircraft, Butterworth-Heinemann, Oxford, 2003, include necessary material for lectures, exercises, assignments, projects and term papers. Require additional materials (handouts, setting assignments, term papers, etc..) Are given at the web site or reproduced on paper. Large-scale electronic materials can be made available to students in direct contact.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 15
laboratory exercises: 0
calculation tasks: 5
seminar works: 0
project design: 0
consultations: 10
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 10
colloquium, with assessment: 0
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 15
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 10
seminar works: 0
project design: 45
final exam: 30

requirements to take the exam (number of points): 35

references

J. B. Russell, Performance and Stability of Aircraft, Butterworth-Heinemann, Oxford, 2003

Helicopters

ID: MSc-0326
teaching professor: Петровић И. Златко
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: aerospace engineering

goals

1. Introduction to rotary lifting surface vehicles.
2. Introduction to rotor aerodynamic theory.
3. Design of helicopters.
4. Performance of helicopters.

learning outcomes

1. Understanding of aerodynamic VTOL schemes.
2. Aerodynamic scheme of helicopters.
3. Mastering theoretical foundations of rotary wing aerodynamics.
4. Ability to estimate of aerodynamic and performance characteristics.

theoretical teaching

In theoretical part the following is taught: VTOL aircraft, Theory of ideal rotor, Blade element theory, horizontal flight of a helicopter, vertical flight performances, horizontal flight performances, Stability of a helicopter, design schemes of a helicopter, helicopter control, Design of rotor blade. EASA regulaations for helicopter and transmission design.

practical teaching

Theory is applied to chosen helicopter. Practical work of the student is monitored by MOODLE. Lectures are downloaded using online access. Homework and other materials to master lectures are supplied. Students do projects in a group and finally present results to other students.

prerequisite

Suggested: Aerodynamic design

learning resources

Lectures in electronic form. Simulations and movies are accessible via MOODLE and internet.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 10

laboratory exercises: 0
calculation tasks: 5
seminar works: 0
project design: 0
consultations: 10
discussion and workshop: 5
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 5
check and assessment of projects: 5
colloquium, with assessment: 0
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 15
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 55
project design: 0
final exam: 30
requirements to take the exam (number of points): 25

references

J. Gordon Lishman, Principles of Helicopter Aerodynamicss, Cambridge Universithy Press
A. R. S. Bramwell, Helicopter Dynamics, Edvard Arnold,, 1976
J. Seddon, Basic Helicopter Aerodynamics, BSP Professional Books, Oxford, 1990

High Speed Aerodynamics

ID: MSc-0309
teaching professor: Стефановић А. Зоран
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: aerospace engineering

goals

The aim of this course is to introduce students to basic concepts in the field of high speed aerodynamics. Emphasis is given to transonic and supersonic flow problems. External flows (supersonic airfoils, wings and aircraft in general) and internal flows (supersonic inlets, nozzles and diffusers).

learning outcomes

Upon completion and passing the course the student expected to understand the basic concepts and problems addressed in the field of aerodynamics at transonic and supersonic speeds. It is expected that the student knows how to apply the acquired knowledge in this field to solve practical engineering problems.

theoretical teaching

In the theoretical part of the course are exposed to the following topics (lessons): Classification of flow and flow model (Navier-Stokes equations, the Euler, the potential of small disturbances, Prandtl-Glauert and Laplace-a). Singularities and discontinuities in the current field. The method of characteristics and conical flow field. Airfoil in transonic and supersonic field (linear airfoil theory and the theory of higher order). Wing in supersonic flow(influence of tips, sweep, delta wing, supersonic and subsonic leading edge). Efusers, nozzles and diffusers.

practical teaching

Practical part of course demonstrate the numerical examples in all areas. Practical work of students is realized through a virtual classroom available 24 hours (program MOODLE). In the workshop students have approach to the professor's written notes, lectures and tests for practice. Practical training includes the preparation of three project tasks. Each student works individually, a condition for the final exam is completing two of the three homeworks.

prerequisite

None. Students which on bachelour studies did not pass any from a group of aerodynamic courses are referred to the additional notes of professors.

learning resources

This course is open a virtual classroom on the Internet. At the first lecture students are enrolled and trained for work (Moodle software). In the workshop approach is performed with the lectures and exercises, guidelines for project design, internet resources, etc..

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 10
laboratory exercises: 0
calculation tasks: 5
seminar works: 0
project design: 5
consultations: 10
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 5
colloquium, with assessment: 0
test, with assessment: 5
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 15
test/colloquium: 15
laboratory exercises: 0
calculation tasks: 0
seminar works: 20
project design: 20
final exam: 30
requirements to take the exam (number of points): 25

references

R.T.Jones: High Speed Wing Theory, Princeton University press, 1999.
H.Ashley: Aerodynamics of Wings and Bodies, McGraw Hill, 1995.

Professional practice M - VAZ

ID: MSc-0612
teaching professor: Бенгин Ч. Александар
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 1
final exam: oral
parent department: aerospace engineering

goals

Practical experience and stay in environment in which the student will realize his professional career. Identifying the basic functions of the business system in the field of design, development and production, as well as the roles and tasks of an mechanical engineer in such a business system.

learning outcomes

Student gets practical experience on the organization and functioning of the environment in which they will apply their knowledge in their future professional career. Student identifies models of communication with colleagues and business information flows. The student recognizes the basic processes in the design, manufacture, maintenance, within the context of his future professional competence. Establish the personal contacts that will be able to use in further education, or entering into future employment.

theoretical teaching

practical teaching

Practical work involves working in organizations that perform various activities related to mechanical engineering. Selection of thematic areas and commercial or research organizations carried out in consultation with the concerned teacher. Generally, a student can perform the practice in manufacturing organizations, project and consulting organizations, organizations concerned with maintaining mechanical equipment, and public utility companies and some of the laboratories at Faculty of Mechanical Engineering. The practice may also be made abroad. During practice, students must keep a diary in which to enter a description of the tasks performed, the conclusions and observations. Following the practice must make a report to defend the subject teacher. The report is submitted in the form of the paper.

prerequisite

There aren’t any compulsory conditions for course attendance.

learning resources

Resources available at the place of professional practice.

number of hours

total number of hours: 46

active teaching (theoretical)

lectures: 0

active teaching (practical)

auditory exercises: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 40
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 0
final exam: 6

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 70
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

Project Management & Air Regulation

ID: MSc-0142
teaching professor: Митровић Б. Часлав
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: project design
parent department: aerospace engineering

goals

Course objective

• Understanding the importance of project management in aviation.
• The creation, introduction and use of aviation projects.
• Determining the functionality of your own projects.
• Preparation, analysis and project management.
• Understanding and preparing the necessary documents for the implementation of projects.

learning outcomes

The acquired knowledge enables the student to:
• Prepare, create and show their own skills,
• Determine the functionality of the aviation project,
• Prepare, perform and manage the development of the aviation project,
• Determine technology of designing an aviation project,
• Recognize the requirements of the local aviation industry in projects,
• Make the necessary documentation of aviation project,
• Implement and collect aviation project.

theoretical teaching

MODERN APPROACHES IN DESIGN (feasibility study, the methodology of improvement, modeling)
Project management (requirements, quality, time, cost, standards)
IMPLEMENTATION OF PROJECTS (initialization, implementation, monitoring and control, cost efficient)
SPECIFICS IN AIRCRAFT DESIGN (strategy in the region; aviation terminology)
WEIGHT AND PERFORMANCE REQUIREMENTS (zones on the aircraft, the speed limit requirements; flight performance)
Aviation law (aviation regulations, certification, airworthiness)
REGULATIONS REGARDING SECURITY (human factors, safety precautions,emergency procedures)
REGULATIONS OF MONITORING AND FLIGHT (planning, defining and tracking the flight operations manual, flight plan revision)
PRACTICAL CONSTRUCTION PROJECT (information gathering, development,simulation of project)

practical teaching

Parameter identification and selection of software for designing. Determination of technology and pricing of the project. Defining the requirements of aircraft weight and performance. The requirements in terms of technological and structural concepts of the aircraft. Aviation security. Aeronautical terminology. Development of wind rose. Speed limit requirements. Aerodynamic design of aircraft performance and sizing, performance requirements takeoff, landing and the other flight regimes. Category airworthiness of the aircraft. Analysis of air regulations. Application of CAD technology. Define data visualization. Defining the contours of the aircraft. The design of the aircraft. Modeling of aircraft structure. Systematization of documentation. Research on aircraft accidents. Analysis of the project.

prerequisite

'defined curriculum of study program / modules'

learning resources

To cope with the case, it is necessary the use of textbooks, manuals for the project, a handout, Internet resources. IT equipment (hardware, CAD workstations, software (CAD, SSO, RRO) pcs. Equipment) ICT, available in the laboratory Aerotechnical Institute).

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 20

active teaching (practical)

auditory exercises: 6
laboratory exercises: 10
calculation tasks: 0
seminar works: 5
project design: 15
consultations: 0
discussion and workshop: 4
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 5
check and assessment of projects: 2
colloquium, with assessment: 0
test, with assessment: 3
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 30
laboratory exercises: 0
calculation tasks: 0
seminar works: 15
project design: 20
final exam: 30
requirements to take the exam (number of points): 35

references

Č. Mitrovic, Aviation regulations, textbook in preparation, full color, A4 format, Faculty of Mechanical Engineering
Air Law , JAA - Joint Aviation Authorities, Theoretical Training Manual, Oxford, 2004
European Aviation Safety Agency, Certification Specifications for Normal, Utility, Aerobatic, and Commuter Category Aeroplanes CS23, February 2009

Structural Analysis

ID: MSc-0629
teaching professor: Динуловић Р. Мирко
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: aerospace engineering

goals

1. introduction to problems and modern calculation methods in stress analysis of aircraft structures, as well as their application to solving real problems
2. introduction to experimental stress analysis of aircraft structures
3.introduction to thin walled structures and composite materials
4. introduction to modern computational methods for stress analysis related to airframe structures

learning outcomes

1. mastering basic structural analysis theories.
2. Application of thery to solve practical problems.
3. Understanding basis of aircraft design process.
4. Understanding modern methods in structural analysis for stress analysis of aircraft structures.

theoretical teaching

In the thoretical part of this course following topics are presented: Variational principle. Principle of virtual work. Minimum energy principle. Rayleigh- Ritz method. Galerkin Method. Colocation method. Finite element method formulation. Convergence Criteria. Finite element formulation for rods and beams. Stifness matrices and wquvalent force matrices. Finite elements for plane stress and plain strain, axial symmetric and volume elements. Automatic mesh generation. Finite elements software. Elastic material models. real structures modeling. Element selection. Mesh density selection.

practical teaching

Substructure modeling. Substructure interaction. Thermal stresses. Initial deformations. Residual stresses. Non-linear models for constitutive equations. Solution methods. Large deformations and large rotations tensor. Stress Tensor formulation for large deformations. Local and global problems in stability analysis. Methos for solving non linear problems. results analysis. Adaptive meshes. Structure optimization. quasistatic and dynamic problems.

In practical part of previous thories are demonstrated in real applications. Numerous problems are analyzed. Practical student work is carried out tohrough mandatory exercises using computers for modeling and analysis. Practical part of the course also includes the vists to the institute VTI for static and dynamic experimentation.

prerequisite

Recommended: Theory of elasticity, Structural analysis of aircraft structures

learning resources

Handouts in e-format, demonstration films and computer simaulation, internet resources

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 10
laboratory exercises: 0
calculation tasks: 5
seminar works: 0
project design: 10
consultations: 5
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 5
colloquium, with assessment: 0
test, with assessment: 5
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 20
laboratory exercises: 0
calculation tasks: 10
seminar works: 0
project design: 20
final exam: 40
requirements to take the exam (number of points): 40

references

Concepts and Applications of Finite Element Analysis, 4th Edition , Cook, Markus and Plesha
Introduction to Aircraft structural Analysis, T. Megson
Structural Analyis with Finite Elements,Hartmann

Windturbines 2

ID: MSc-0545
teaching professor: Симоновић М. Александар
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: aerospace engineering

goals

In the course of Wind turbines 2, the student will be acquainted with analysis and design principles of wind turbines and its parts. Beside the detailed study of different wind turbine designs, issues regarding regulation and dynamic balancing, the student will be in opportunity to gain knowledge about numerical simulations and flow, structural and modal analysis of wind turbine components, as well as basic principles of optimization of rotors for various operating conditions.

learning outcomes

The student will gain following subject-specific skills by mastering the curriculum:
- thorough knowledge and understanding of different wind turbine concepts and design methods;
- skills needed for wind turbine and its parts selection according to given operating conditions using scientific methods and procedures;
- integration of fundamental knowledge in mathematics, programming, mechanics and fluid mechanics and application to design and calculations of wind turbines;

theoretical teaching

- Introduction to wind energy;
- Historical review of wind energy technology development;
- Components of wind turbines – analysis and design of rudimentary assemblies; Wind characteristics; Flow analysis through the wind turbine rotor; Calculation and optimization of characteristics; Wind turbine blade structure and load – analysis of stress-strain state; Numerical simulation of flow through wind turbines' rotor; Pumps powered by wind energy; Electrical system – basic concepts, generator types, power accumulation, grid-connected systems, losses in the system; Control systems – control influence on rotor, active and passive modes of power control; Oscillations in wind energy systems – modeling; Aerodynamic and structural optimization – numerical methods of optimization; Methods for testing of wind turbines – static and dynamic testing

practical teaching

- Demonstration of different wind turbine designs
- Rudimentary assemblies and subassemblies of wind turbines
- Devices for wind speed measurements – anemometers
- Dimensioning of wind turbine blades – numerical simulation of airfoil flow and blade dimensioning
- Performance calculations – development and application of existing software for wind turbine performances
- Stress-strain state analysis of wind turbine blades and rotor
- Static tests of blades
- Dynamic tests of blades

prerequisite

There are not any compulsory conditions for course attendance.

learning resources

1. Pešić S. Wind energy – AErodynamics of wind energy systems with horizontal axis of rotor, Faculty of Mechanical Engineering, Belgrade, 1994 (in Serbian)
2. Petrović Z, Stupar S, Fundamental Equations of Aerodynamics, Mechanical Engineering Faculty,1997
3. Additional materials (handouts, exercises and instructions for solution of the exercises)

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 10
laboratory exercises: 12
calculation tasks: 0
seminar works: 8
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 2
check and assessment of seminar works: 4
check and assessment of projects: 0
colloquium, with assessment: 4
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 15
laboratory exercises: 15
calculation tasks: 15
seminar works: 15
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

agricultural engineering

Attached agricultural machines and equipments
Designing agricultural machines
Designing agricultural machines and equipment
Explatation and maintanance of of agricultural machines and equipment
Fundamental transport phenomena and drying techniques
Geoinformation and remote control of biotechnic systems
Managing food safety and quality
Plant and process design and energy systems
Plant design for food production and processing
Processing technology of agricultural products
Professional practice M - IBS
Special techniques and technology of drying
Technological processes in agro complex
Technological processes in agro complex
Tractors and self-propelled agricultural machines

Attached agricultural machines and equipments

ID: MSc-0175
teaching professor: Вељић М. Милан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: agricultural engineering

goals

1. Achieving competence and academic knowledge relating to the termination of agricultural machinery. 2. Mastery of specific practical skills for the selection, aggregation and regulation of agricultural machinery and auxiliary equipment. 3. Basic notions related to the manufacture, use and working elements of machines as part of the aggregate.

learning outcomes

1. Mastering the program through analysis, optimization and synthesis of certain procedures and solutions. 2. Development of critical thinking and approach to problems of development connecting agricultural machines. 3. Thematic knowledge and understanding and combining knowledge from agribusiness and engineering.

theoretical teaching

1. Aggregating connecting agricultural machines. System connection for drive-wheeled machine. 2. Operating elements - tools of agricultural machinery. The specificity of the tools in the numerous requests. 3. Support structure of agricultural machinery. Impact resistance to the concept and structure of the bearing structures. The influence of structural solutions to the mass and cost of agricultural machinery. 4. Machine with an active working elements. Rotary, linear and complex motion of working elements. 5. Performing multiple tasks in one pass. 6. Specifics and technical characteristics of groups of machines for soil tillage, fertilization, seeding, planting, plant protection and harvesting. Agro-technical requirements. 7. Handling stability. Load distribution. Lean elements, wheels and sliders.

practical teaching

1. Auditory exercises: Introduction to the review of technical systems in the connection of agricultural machinery. 2. Laboratory Exercises: Laboratory work in determining the path of active work tools for soil cultivation, mowing and brought stalks of grain harvesters. Production in electronic form influence the path of movement of tools on top of the function of the geometric and kinematic parameters. 3. Production of the paper: Working in the field machine for fertilizing, planting, sowing, care and maintenance of the plant crops.

prerequisite

Defined curriculum of student programs/modules and exams passed and 7.1.5
7.2.5.

learning resources

1. Veljić M. Technological processes of mechanized agriculture. MF., Bgd, 1977,
2. Veselinov B., Martinov M., Bojic C., Machinery for Biosistems 1, practicum, FTN Novi Sad, 2009.
3. Laboratory installation for determining the path of the blade, instructions.

4. Equipment in the laboratory POM (LMS).
5. Lectures in electronic form.
6. Instructions for preparation of the paper.
7. Renowned copy of the paper.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 14
laboratory exercises: 4
calculation tasks: 0
seminar works: 10
project design: 0
consultations: 2
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 2
check and assessment of seminar works: 4
check and assessment of projects: 0
colloquium, with assessment: 4
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 20
laboratory exercises: 10
calculation tasks: 0
seminar works: 30
project design: 0
final exam: 30
requirements to take the exam (number of points): 50

references

Tesic M., Principle of operation of machines for harvesting grass material, FTN, 1984.
Martinov M., Markovic D., Machinery and tools for soil cultivation, the first part, FTN, Novi Sad, 2002.
Veljić M., Viewing construction of agricultural machinery, MF, Belgrade, 1992.

Designing agricultural machines

ID: MSc-0108
teaching professor: Вељић М. Милан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: agricultural engineering

goals

1. Achieving competence and academic knowledge relating to agricultural machinery. 2. Mastery of specific and practical skills for carrying out of agricultural machines. 3. Findings to a multidisciplinary approach to achieve optimal results in the design of agricultural machines.

learning outcomes

1. Mastering the methods and processes of design. 2. Fundamental knowledge of theories of agricultural machinery. 3. The use of knowledge and transfer of new technologies in the field of design and construction of agricultural machines. 4. Monitoring and implementation of new and contemporary solutions.

theoretical teaching

1. Technical and economic requirements in the design of agricultural machines. 2. The theory of cutting tillage. 3. The forces acting on the plugging of the body. The stability of the plow. 4. The main parameters of working elements and machines for additional processing of land. Design of machinery with an active working elements. Disc machines with working elements. Conceptions of cultivators, harrows and rollers. The main parameters and design machines to perform several tasks in one pass. 5. Characteristics and design of machinery for fertilizing, seeding and planting. 6. Machines for chemical pesticides and irrigation equipment. 7. Designing machines to harvest the yields.

practical teaching

1. Auditory exercise: a review of contemporary solutions of agricultural machinery for soil preparation. Displaying solutions machine fertilizing, seeding, planting, plant protection and irrigation. Displaying solutions for machine sorting of agricultural crops: forage, grains, yields of root and tubers, vegetables and fruits. 2. Development of the project: The project in the field of agricultural machinery and equipment. Determination of basic parameters. Budget, schedule and technical documentation. 3. Development of arithmetic problems: The task of designing working surface plow body. The task in the field of cutting device. The task in the field of combine harvester. 4. Laboratory Exercise: Profiling working surface plow body.

prerequisite

Passed exams in 7 semesters (defined curriculum study program/ module) and passed items 7.1.5, 7.2.5, and 8.1.5 of the module POM

learning resources

1.Veljić M.: Technological processes of mechanized agriculture, MF, Belgrade, 1997.
2. Laboratory installation for profiling working surface plow body, instructions.
3. Veljić M., Written lectures, Belgrade, 2008.
4. Veljić, M.: Instructions for making assignments for the design of the working surface plow

body.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 10
laboratory exercises: 4
calculation tasks: 4
seminar works: 0
project design: 10
consultations: 2
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 2
check and assessment of lab reports: 2
check and assessment of seminar works: 0
check and assessment of projects: 2
colloquium, with assessment: 4
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 10
laboratory exercises: 10
calculation tasks: 10
seminar works: 0
project design: 30
final exam: 30
requirements to take the exam (number of points): 50

references

Gligoric R., Mechanisms of agricultural machinery with the settlement tasks, PF, Novi Sad, 2005.
Veljić M., Viewing construction of agricultural machinery, MF, Belgrade, 1992.
Urosevic M., Machinery and apparatus for the application of pesticides, PF, Belgrade, 2001.
Martinov M., Markovic D., Machinery and tools for soil cultivation, the first part, FTN, Novi Sad, 2002.

Designing agricultural machines and equipment

ID: MSc-0616
teaching professor: Марковић Д. Драган
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: agricultural engineering

goals

1. Achieving competence and academic knowledge relating to agricultural machinery and equipment. 2. Mastery of specific and practical skills for carrying out of agricultural machines and equipment. 3. Findings to a multidisciplinary approach to achieve optimal results in the design of agricultural machines and equipment.

learning outcomes

1. Mastering the methods and processes of design. 2. Fundamental knowledge of theories of agricultural machinery and equipment. 3. The use of knowledge and transfer of new technologies in the field of design and construction of agricultural machines and equipment. 4. Monitoring and implementation of new and contemporary solutions.

theoretical teaching

1. Technical and economic requirements in the design of agricultural machines and equipment. 2. The theory of cutting tillage. 3. The forces acting on the plugging of the body. The stability of the plow. 4. The main parameters of working elements and machines for additional processing of land. Design of machinery with an active working elements. Disc machines with working elements. Conceptions of cultivators, harrows and rollers. The main parameters and design machines to perform several tasks in one pass. 5. Characteristics and design of machinery for fertilizing, seeding and planting. 6. Machines for chemical pesticides and irrigation equipment. 7. Designing machines to harvest the yields.

practical teaching

1. Auditory exercise: a review of contemporary solutions of agricultural machinery for soil preparation. Displaying solutions machine fertilizing, seeding, planting, plant protection and irrigation. Displaying solutions for machine sorting of agricultural crops: forage, grains, yields of root and tubers, vegetables and fruits. 2. Development of the project: The project in the field of agricultural machinery and equipment. Determination of basic parameters. Budget, schedule and technical documentation. 3. Development of arithmetic problems: The task of designing working surface plow body. The task in the field of cutting device. The task in the field of combine harvester. 4. Laboratory Exercise: Profiling working surface plow body.

prerequisite

Passed exams in 7 semesters (defined curriculum study program/ module) and passed items 1.1.5, 1.2.5 of the module IBS

learning resources

1.Veljić M.: Technological processes of mechanized agriculture, MF, Belgrade, 1997.
2. Laboratory installation for profiling working surface plow body, instructions.
3. Veljić M., Written lectures, Belgrade, 2008.

4. Veljić, M.: Instructions for making assignments for the design of the working surface plow body.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 10
laboratory exercises: 4
calculation tasks: 4
seminar works: 0
project design: 10
consultations: 2
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 2
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 4
colloquium, with assessment: 4
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 10
laboratory exercises: 10
calculation tasks: 10
seminar works: 0
project design: 30
final exam: 30
requirements to take the exam (number of points): 50

references

Gligoric R., Mechanisms of agricultural machinery with the settlement tasks, PF, Novi Sad, 2005.
Veljić M., Viewing construction of agricultural machinery, MF, Belgrade, 1992.
Urosevic M., Machinery and apparatus for the application of pesticides, PF, Belgrade, 2001.
Martinov M., Markovic D., Machinery and tools for soil cultivation, the first part, FTN, Novi Sad, 2002.

Explatation and maintanance of of agricultural machines and equipment

ID: MSc-0199
teaching professor: Вељић М. Милан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: agricultural engineering

goals

1. Achieve competence and mastery of methods and a thorough knowledge of the area of servicing of agricultural machines and equipment. 2. Development of creative skills necessary for the implementation of existing tasks. 3. Acquisition of basic knowledge relating to the operation and maintenance of agricultural machinery and equipment.

learning outcomes

1. Mastering the methods of maintenance processes. 2. Applying knowledge in practice. 3. Cooperation with the international environment in the area of operation and maintenance. 4. Linking with multidisciplinary areas, primarily sent agronomy, economics and management. 5. Monitoring and implementation of innovations in the profession.

theoretical teaching

1. Specifics of the exploitation of agricultural machines and equipment. Working conditions. Influence the type and condition of material that is subject to processing, and climatic conditions on the performance of machinery and equipment. 2. Determine the quality of tillage. Determine the quality of the variants, and chemical protection of plants primarily through the indicators of ecology and environmental protection. Determination of quantitative and qualitative losses in regulating the crops. 3. Failures of technical systems. Standards for design, construction and maintenance. Ties of working conditions and dismissal. Terminations for input connection and self-propelled agricultural machines. Maintenance technologies. Reliability. Preventive and corrective maintenance. 5. Organization of maintenance and service. Service points. Basic characteristics, conditions and purpose dimensions of the building. 6. Spare parts. Delivery and storage of spare parts.

practical teaching

1. Auditory training: the exploitation of agricultural machines in various application conditions. An indication of quality tillage. Way of testing. View of determining the optimal distribution of material during fertilization and chemical protection of plants. Comparative study to determine the characteristics of exploitation and loss of quality and quantity of material to be processed. An example of cause and consequence of failure. System Reliability. Example maintenance technology of agricultural machines. Example of repair workshops and storage of spare parts. 2. Term paper: Refers to the maintenance of agricultural machinery, the concept of service, storage and installation of spare parts and necessary resources in the machine park and the labor force. Economic justification.

prerequisite

Attended VII semester courses and exams passed object module number 7.1.5 and 7.2.5.

learning resources

1. Written excerpts from the case.
2. Veljić M., Operational readiness of agricultural machinery, Vedes, Belgrade, 2011.
3. Instructions for making the data of the paper.
4. Laboratory measuring system for determining losses, instruction.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 15
laboratory exercises: 0
calculation tasks: 0
seminar works: 10
project design: 0
consultations: 3
discussion and workshop: 2
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 6
check and assessment of projects: 0
colloquium, with assessment: 4
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 20
laboratory exercises: 0
calculation tasks: 0
seminar works: 30
project design: 0
final exam: 40
requirements to take the exam (number of points): 50

references

Todorovic S., Engineering Maintenance Technical Systems, School of Medicine, Belgrade, 1993
.
Bozic S., Maintenance and repair of technical systems in agriculture, PF, Belgrade, 2004.
Soldat D., Grujic N., Maintenance of machinery and equipment, Monograph, HTS Zrenjanin, 2009.

Fundamental transport phenomena and drying techniques

ID: MSc-0463
teaching professor: Топић М. Радивоје
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: agricultural engineering

goals

Mastery of theoretical and practical knowledge in the field of heat and mass transfer in the drying process of wet material (colloidal, colloidal capillary porous and porous capillary) and introduction to techniques of drying process (convective drying), which includes the development of creative skills and mastering specific skills to perform practical work tasks.

learning outcomes

Practical and theoretical knowledge about the laws of process (heat and mass transfer), kinetics and dynamics of the drying process, techniques and methods of selection of rational methods and optimal regime of the drying process, which involves applying knowledge in practice, solving practical problems using scientific methods and procedures and monitoring and implementation of innovations in the profession.

theoretical teaching

1.0. Basic laws of transport phenomena in wet materials: Heat transfer in moist materials; Transfer of moisture in wet materials. 2.0. The transfer of heat and moisture in wet materials: Thermal diffusion of moisture in gases and solutions; Thermal diffusion of moisture in colloidal bodies; Heat mass transfer in capillary porous bodies; Heat mass transfer in colloidal capillary porous bodies; The basic laws of heat and mass transfer. 3.0. The basic ways of thermal drying. 4.0. The design and calculation of facilities for drying; Material balance of dryer; Heat balance dryer; Determining the flow of drying agent. 5.0. The calculation of belt driers. 6.0. Calculation of batch dryers: Dimensioning of the basic components dryer; Fan selection; Determination of fuel flow rate and thermal efficiency; Dryers; Determination of basic dimensions of the furnace. 7.0. Calculation of the drum dryer. 8.0. Calculation of the fluidized bed dryer. 9.0. The calculation of pneumatic dryers: Calculation of pneumatic tube dryers; Calculation of vortex dryer. 10.0. Calculation of the spray-drying materials, spray driers. 11.0. Calculation of combined dryers: Calculation of combined cyclone dryers; Calculation of air-fountain combined dryers. 12.0. Calculation of cabinet dryer. 13.0. Calculation of tunnel dryers.

practical teaching

Practical work: making term papers from these theoretical entities in order to learn about existing solutions and drying techniques and monitoring the development in the area; computational tasks: the thermal calculation of different drying methods and types of dryers from the aspect of drying (convective drying) and the state, shape and dimensions of materials; introduction to systems of characteristic differential equations, their performance and the basic criteria of similarity of heat transfer and mass transfer.

prerequisite

defined curriculum of study program / module

learning resources

1. Topic M. Radivoj, Basics of calculations, design and construction of dryers, Scientific Book, Belgrade, 1989. 2. Topic M. Radivoj,Bogner Martin, Drying techniques, Institute for publishing textbooks and teaching aids, Belgrade, 2002., KPN, 3. Topic M. Radivoj, Fundamental transport phenomena and drying techniques (Handouts for lecture). Examples of performed computational tasks. Various tables and practicum.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 0
laboratory exercises: 0
calculation tasks: 5
seminar works: 10
project design: 15
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 3
check and assessment of projects: 5
colloquium, with assessment: 0
test, with assessment: 2
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 20
test/colloquium: 10
laboratory exercises: 0
calculation tasks: 0
seminar works: 25
project design: 15
final exam: 30
requirements to take the exam (number of points): 35

references

Sazhin, S .B (1984), Fundamentals of drying techniques, "Chemistry", Moscow.
Ginsburg, S. A (1973), Foundations of the theory and technique of drying foods, "Food Industry", Moscow.
Lykov V. A, (1958), Heat and mass transfer in drying processes, State publishing house, Moscow.
Lykov V. M (1970), Dying in the chemical industry, The publishing house "Chemistry", Moscow.
Lebedev P. D (1956), Industrial Heat Engineering, National Energy Publishing House, Moscow - Leningrad.

Geoinformation and remote control of biotechnic systems

ID: MSc-0615
teaching professor: Марковић Д. Драган
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: agricultural engineering

goals

1. Master the theoretical foundations of measurement and automation of agricultural machines and equipment; 2. Principles of measurement, sensors and methods of measurement non-electrical quantities on agricultural machines and equipment; 3. Automation of tractors and machines; 4. Automation combines: automatic control, regulation of technological devices, measurement and regulation of losses, monitoring, 5. Management in precision agriculture and food processing industry. 6. Monitoring of dinamic machines and proceses in real time

learning outcomes

1) Fundamental knowledge in the field of measurement and automation of agricultural machines and equipment; 2. Mastering the principles of measurement, sensors and methods of measuring non-electrical quantities on agricultural machines and equipment; 3. Automation of tractors, trailers, harvesting equipment and machinery in food processing industry; 4. Management in precision agriculture GPS and processing industry; 5. Acquisition of practical skills and application in practice.

theoretical teaching

1. Introductory discussion of theoretical bases and methods of measurement and automation of agricultural machines and equipment: navigation leveling measurements, measuring distance (distance, measuring the number of revolutions and torque measuring yield loss measurement, the measurement of quantity and measurement of other parameters; 2 Principles of measurement, sensors , division, operating principles, static and dynamic characteristics, a method of measuring non-electrical quantities on agricultural machines and equipment, can bus system; third Automation tractors and machinery: automatic control of loading, automatic control of connection devices and machines on the tractor, the tractor can bus , automatic control and information systems; 4 combines automation: automatic control of the direction, regulation of the position Header, perform separation and other technological devices (automatic leveling), measurement and regulation of losses, monitoring of combine harvesters; fifth management in precision agriculture GPS and DGPS and automation systems and production lines in food processing industry.

practical teaching

Laboratory exercises:
1. Measurements of kinematic characteristics of agricultural machinery and equipment;
2. Measurements of energy parameters of agricultural machines and equipment.
Essay by selecting candidates from the field:
1. Automation of tractors and agricultural machines and devices;
2. Automation of universal self-propelled combine harvesters;
3. Automation of self-propelled harvester for vegetables and industrial crops;
4. Automation equipment and technological lines for food processing;
5. Application of GPS and DGPS in precision food production (Precision Farming).

prerequisite

Attended courses of previous years of study and all the conditions defined curriculum of study program / module

learning resources

1. Markovic D.: Automation in agriculture, written lectures and lectures in electronic form, Belgrade, 2007.
2. Markovic D.: Transport in Agriculture, Belgrade, 1997.
3. Automation and measurement of agricultural machinery-handouts.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 10
laboratory exercises: 10
calculation tasks: 10
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 5
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 3
test, with assessment: 2
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 20
laboratory exercises: 20
calculation tasks: 20
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 50

references

Martinov M., My tractor, Res trade, Novi Sad, 2007.
Zivanovic Z., N Janićijević., Automatic transmission vehicles, Belgrade, 2000.
Ribar Z., Control systems, MF in Belgrade, Belgrade 2008.
Bolton W., Instrumentation control systems, EUSEVIER SCIENCE & TEHNOLOGY BOOKS, 2004.
Popovic M., Sensors and measurements, Department of textbooks and teaching aids, Srpsko Sarajevo, 2004.

Managing food safety and quality

ID: MSc-0596
teaching professor: Марковић Д. Драган
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: agricultural engineering

goals

1.The subject should enable students to acquire knowledge about the concept of certification and its importance for the market, environmental protection and good agricultural practice, the function of certification.
2.Introduction to basic procedures for certification, certification course, participants, their rights and obligations, the general principles of all standards relating to food and industrial processing of food products and exposure with institutions and organizations dealing with food safety in Serbia and abroad.
3.The subject should enable students to acquire knowledge / understanding of contemporary approaches and principles of quality management, quality management functions of the organization, specific methods of management and quality control, new business strategies, new systems and specific quality management activities.
4.Learning about new trends in food production.

learning outcomes

1.Fundamental knowledge about the concept of certification and its role in the market of food products, environmental protection and good agricultural practices in the function of certification.
2.The student should be able to connect the basic engineering knowledge with development trends in food production and processing along with the application of regulations and standards.
3.Introduction of skills, consistent and systematic improvement of application of modern, efficient and effective quality management system.

theoretical teaching

Introductory considerations. Prerequisites food safety management. The concept of standardization. The principles and benefits of standardization. regulations and standards applied in agriculture and food industry. The quality management system in food production. The quality of food products. Overview of institutions and organizations dealing with food safety in Serbia and abroad. New trends in food production. Environmental protection.

practical teaching

Practical teaching coupled with interactive lessons take place in the field of modern quality management system operations, the food industry and safety management and quality of products (food). The way the accreditation of laboratories and the introduction of standards in the control of production flows. Planned are two tests and essay.

prerequisite

Attended courses of previous years of study and all the conditions defined curriculum of study program / module

learning resources

1. Markovic D.: Written lectures, Belgrade, 2007.
2. Djekic, I., (2009) Environmental management in food production. University of Belgrade, Faculty of Agriculture
3. D. R. Heldman.; D. B. Lund.: Handbook of food engineering; Taylor & Franncis Group; New York, 2007.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 20
laboratory exercises: 0
calculation tasks: 0
seminar works: 10
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 4
check and assessment of projects: 0
colloquium, with assessment: 6
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 40
laboratory exercises: 0
calculation tasks: 0
seminar works: 20
project design: 0
final exam: 30
requirements to take the exam (number of points): 50

references

Grujic, R., Radovanovic, R. (2007): Quality management and safety in food production. University of Banja Luka, Faculty of Technology (RS / BiH)
Radovanovic, R., Rajkovic, A. (2009): Managing security in the process of food production. University textbook. University of Belgrade - Faculty of Agriculture
Carol Wallace, William Sperber, Sara E. Mortimore: Food Safety for the 21st Century, ,UK, 2011.
Djekic, I., (2009) Environmental management in food production. University of Belgrade, Faculty of Agriculture
Grujic, R. et al. : Quality and Food Analysis, Faculty of Technology in Banja Luka, RS / BiH. 2001

Plant and process design and energy systems

ID: MSc-0464
teaching professor: Топић М. Радивоје
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: agricultural engineering

goals

Mastering the knowledge necessary for the calculation and design of plant and process and energy systems and their use. This includes the development of creative abilities and mastery of specific practical skills for performing tasks in engineering practice.

learning outcomes

Knowledge necessary for plant and process design and energy systems and their exploitation, which involves applying knowledge in practice, solving practical problems using scientific methods and procedures and monitoring and implementation of innovations in the profession.

theoretical teaching

1.0. Introductory remarks. 2.0. Historical development of the facilities with protected space: Review of typical solutions; Basic ways of providing microclimate; Basic systems for the provision of micro-climate; Definition of working conditions of the protected space objects and calculations; Thermo-technical calculations and defining the mathematical model; Definition and development of a program for optimization of buildings with protected space. 3.0. Design of devices and installations for drying; Calculations for pneumatic - rotary and rotary dryers; Determination of structural parameters of pneumatic - rotary dryers; Constructive dimensions of multipass rotary dryer chamber; Methods of determining the drying regime. 4.0. Wind turbine theory, the coefficient of efficiency of wind energy: Aerodynamic characteristics of wind turbines; Control systems for rotation speed and power output of wind turbines, and auto orientation of wind turbine circuit when the direction of the wind change; Selection of solution and calculation of power of the wind turbine; Main components of the wind power plant. 5.0. Design of biogas plants: The principle of constructing the digester; Heating the substrate; Sizing of pipe heaters; Insulation of digester vessels. 6.0. Design of biomass power plants: Basic principles of energy valorization; Briquetting; Pelletizing; Cogeneration and trigeneration; Concept solutions for high temperature saw dust drying plant. 7.0. Heat pump: Ground connection

practical teaching

Practical Studies: Seminar paper is given out some of these theoretical entities in order to introduce students to existing solutions, their characteristics and monitoring developments in the field covered by the syllabus. Laboratory Exercise: Determining floating rate of various materials (depending on the type, shape, size, humidity, etc.).. Calculations are made for the purpose of defining and dimensioning of characteristic solutions of some of the theoretical whole. A project is made with the technical documentation depending on the selected theoretical entities, which is a continuation of the development of computational tasks. Projects include the choice of concepts for plant and process design and energy systems, calculation and dimensioning of components and corresponding drawings.

prerequisite

defined curriculum of study program / module

learning resources

1. Topic M. Radivoj, Basics of design, Calculation and construction dryers, Scientific Book, Belgrade, 1989., KPN; 2. Topic M. Radivoj, Design and construction of agricultural facilities (theory and laboratory exercises performed), Faculty of Mechanical Engineering, 1996., PRA, 3. Topic M. Radivoj, Martin Bogner, Drying technology, the Institute for publishing and teaching aids, Belgrade, 2002., KPN
4. Topic M. Radivoj, Plant and process design and energy systems, 2009. (Handouts for lecture). Example of finished projects and term papers. Various guidelines and standards.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 0
laboratory exercises: 0
calculation tasks: 10
seminar works: 5
project design: 15
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 4
check and assessment of projects: 4
colloquium, with assessment: 0
test, with assessment: 2
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 20
test/colloquium: 10
laboratory exercises: 0
calculation tasks: 10
seminar works: 20
project design: 10
final exam: 30
requirements to take the exam (number of points): 35

references

Фатеев M. E., (1946), Wind turbines, State energy publisher, Leningrad.
Duffy A. J., Beckman AW, (1977), Thermal Processes with use of solar energy , MIR, Moscow.
Knap V., Kulišić P., (1985), New sources of energy, School Book, Zagreb
Labudović B., (2002), Renewable Energy, Energy Marketing Ltd., Sokolska 25, Zagreb
KTBL - Scripture 273., (1981), Energy of agricultural products, Darmstadt.

Plant design for food production and processing

ID: MSc-0158
teaching professor: Марковић Д. Драган
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: agricultural engineering

goals

1. Master the theoretical foundations of the design of machinery, equipment and technological lines for manufacturing and food processing; 2 Getting to know your limitations and the specific production lines and food processing; 3 Introduction to the principles of the design of machinery and equipment manufacturing and food processing; 4 Acquire practical skills in analyzing the set of engineering problems and its solving multidisciplinary approach.

learning outcomes

1) A basic understanding of technology and food processing, 2) Basic knowledge in designing production lines and food processing, 3) Analysis and synthesis of design solutions and acquiring methods of optimization; 4) Connect the basic engineering knowledge and to achieve synergy; 5) Introductions with the development trends in food production and processing, 6) The acquisition of practical skills in designing production lines and food processing and its application to practice.

theoretical teaching

1) Engineering in food production and processing - the basic parameters, symbols and standards, machinery and equipment and their connection in the technological process, 2) materials for the food and biotechnology - classification, characteristics and behavior of materials, structures, materials, material selection, 3) Transportation systems and pipelines, support structure and joints, 4) Transport pathways in the house - people, raw materials, by-products, finished goods, packaging, waste, energy, transport vehicles, 5) Material - energy balances and 6) optimization of equipment and resources; 7) The requirements of food production - standards and regulations relating to machinery, equipment and facilities, and 8) Project documentation - conceptual design, machine design, other projects of interest, 9) The share of engineers in the lifetime of the building - from concept to commissioning plants in operation.

practical teaching

Seminars
1. Analysis and calculation capacity lines for manufacturing and food processing: technological line for production and fruit processing, production lines for manufacturing and processing of vegetable preservation, technological lines for production and meat processing, dairy, grains and seeds,...). Defining the layout of machinery and equipment, analysis of the balance of materials, raw materials, fuels and fluids and transport routes.
Project
Development of conceptual design complete production lines for manufacturing and food processing by choosing from the topics listed in the essays.

prerequisite

Attended courses of previous years of study and all the conditions defined curriculum of study program / module

learning resources

1. CIGR-HANDBOOK Agricultural Engineering, Agro Processing Engineering, ASAE, USA, 1999.
2. Srivastava KA, Goering EC, Rohrbach PR: Engineering Principles of Agricultural Machines, ASAE, USA, 1993.
3. Markovic D.: Written lectures, Belgrade, 2007.
4. Example of a project.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 10
project design: 20
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 3
check and assessment of projects: 7
colloquium, with assessment: 0
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 10
project design: 50
final exam: 30
requirements to take the exam (number of points): 50

references

Zlatković B. . The technology of processing and storage of fruit., published by University of Belgrade, Faculty of Agriculture 2002nd
Moser E.:Verfahrenstechnik Intensivkulturen,Verlag Paul Parey,Univerzitet Hohenhein,2005.,Nemacka
Karel M., Lund D. B., Physical principles of food preservation, Marcel Dekker inc., New York, 2003.
Heldman D. R., Handbook of food engineering, Taylor & Franncis Group, New York, 2007.
M. Veres. Basics of food preservation, Belgrade, 2004.

Processing technology of agricultural products

ID: MSc-0600
teaching professor: Марковић Д. Драган
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: seminar works
parent department: agricultural engineering

goals

1. Student should master the basics of the process of agricultural products(fruits, vegetables, animal products and grains)..
2. Understanding the limitations and specific lines of production and food processing.
3. Introduction to the preparatory process technologies of processing agricultural products (cleaning, washing, sizing and sorting round).
4. Mastering how to process modeling and optimization processes of food preservation using high and low temperatures.
5. Acquiring knowledge about the procedures and equipment for sterilization and pasteurization of food products.
6. Acquiring knowledge about the procedures and devices for cooling and freezing of fruits and vegetables.
7. Understanding the technology of cooling fruits and vegetables.
8. Understanding the technological procedures for freezing and storing fruit and vegetables.
9. Introduction to methods and devices for thawing food product.

learning outcomes

Upon completion of the course, students will be able to properly projected lines for the production of certain types of products. To enable students to study in the preparation and preservation of food using high and low temperatures. Design of technological processes of cleaning, washing, calibration, color sorting, heat treatment of fresh products (blanching), heat treatment of the finished food product (pasteurization, sterilization), cooling, freezing and storage. Knowledge of changes that could threaten the quality of agricultural products in cold storage. Implement measures to prevent damage to fruit and vegetables during storage in cold storage. Knowledge and application of international standards of quality frozen food products.

theoretical teaching

Introductory considerations.Fundamentals of animal products processing technology. Basis of the preparatory process of fruits, vegetables and grains. Washing, cleaning and calibration of fresh fruits and vegetables. Color sorting of fresh and frozen products. Fundamentals of preservation of fruits, vegetables and ready-made food products using high and low temperatures. Heat treatment of fresh products (blanching). Heat treatment of the finished food product (pasteurization and sterilization). Cooling technology and storage of animal products. The technology of cooling and storage of fruits and vegetables. Preservation by freezing. Technology freezing of agricultural products. Effects of freezing rate on quality of frozen products. The changes that occur during freezing of products. Concept and models of refrigerator thermal insulation, cooling fluids, methods for achieving low temperatures, storage, maintenance of the given regime, transport of chilled and frozen fruits and vegetables. Thawing.

practical teaching

Seminar papers

1.Analysis of technologies for producing and processing fruit,
2.Analysis of technology for production and processing of vegetables,
3.Analysis of technologies for production and processing of grains and seeds,
4.Analysis of technology, machinery and equipment for production and processing of meat and dairy products.

prerequisite

Attended courses of previous years of study and all the conditions defined curriculum of study program / module

learning resources

1. Markovic D.: Written lectures, Belgrade, 2007.
2. M. Karel., D. B. Lund.: Physical principles of food preservation; Marcel Dekker Inc; New York, 2003.
3. D. R. Heldman.; D. B. Lund.: Handbook of food engineering; Taylor & Franncis Group; New York, 2007.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 20
laboratory exercises: 0
calculation tasks: 0
seminar works: 10
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 4
check and assessment of projects: 0
colloquium, with assessment: 6
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 40
laboratory exercises: 0
calculation tasks: 0
seminar works: 20
project design: 0

final exam: 30
requirements to take the exam (number of points): 50

references

Miodrag A. Jankovic. "Cooling Technology", published by University of Belgrade, Faculty of Agriculture 2002.
Branislav P. Zlatković.: "The technology of processing and preserving of fruits", published by University of Belgrade, Faculty of Agriculture 2002.
Sava Vujic. "Refrigeration", published by Faculty of Mechanical Engineering, University of Belgrade, 1996.
M. Veres.: Basics of food preservation, Belgrade, 2004.
Thompson, A. K., Fruit and Vegetables: Harvesting, Handling and Storage, Blackwell Pub, 2003.

Professional practice M - IBS

ID: MSc-0502
teaching professor: Марковић Д. Драган
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 1
final exam: project design
parent department: agricultural engineering

goals

Practical experience and stay in the student environment in which the student will realize his professional career.
Identifying the basic functions of the business system in the field of design, development and production, as well as the roles and tasks of mechanical engineering in such a business system.

learning outcomes

Students get practical experience on the organization and functioning of the environment in which they will apply their knowledge in their future professional career. Student identifies models of communication with colleagues and business information flows. The student recognizes the basic processes in the design, manufacture, maintenance, in the context of his future professional competence. Establish the personal contacts and poznastva that will be able to use at school or entering into future employment.

theoretical teaching

Selected topics through practical activities.

practical teaching

Practical work podrazumva work in organizations that perform various activities in connection with mechanical engineering. Selection of thematic areas and commercial or research organizations carried out in consultation with the concerned teacher. Generally a student can perform the practice in manufacturing organizations, project and consulting organizations, organizations engaged in mechanical equipment maintenance, and public utility companies and some of the laboratories at Faculty of Mechanical Engineering. The practice may also be made abroad. During practice, students must keep a diary in which to enter a description of the tasks performed, the conclusions and observations. Following the practice must make a report to defend the subject teacher. The report is submitted in the form of the paper.

prerequisite

Students of modul IBS

learning resources

Laboratory and IT equipment

number of hours

total number of hours: 46

active teaching (theoretical)

lectures: 0

active teaching (practical)

auditory exercises: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 0
final exam: 46

assessment of knowledge (maximum number of points - 100)

feedback during course study: 70
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 50

references

Markovic D.: Transport in Agriculture, Belgrade, 1997.

Special techniques and technology of drying

ID: MSc-0462
teaching professor: Топић М. Радивоје
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: agricultural engineering

goals

Acquire basic knowledge in the field of special techniques and technologies of drying process (drying by radiation, osmosis, ultrasound, conductive, sublimation, in a stream of high and super high frequency, etc.), which includes the development of creative abilities and mastery of practical skills for specific job performance.

learning outcomes

The ability to use acquired knowledge to solve problems in the field of special techniques and technologies in the process of drying, kinetics and dynamics study of the drying process, the drying process and design solutions, including application of knowledge in practice, solving practical problems using scientific methods and procedures and monitoring and implementation of innovations in profession.

theoretical teaching

1.0. Methods of extraction of moisture and classification of thermal energy to the drying characteristics. 2.0. Thermoradial drying: Thermoradial dryers with electrical and gas heating; Thermoradial dryer with an electric heating; Thermoradial dryers with gas as a heat source; Method of heat drying calculation for thermoradial dryers. 3.0. Contact drying of materials: Contact drying of the material by heating surface; Dryers for contact drying; Drying materials in liquid environments; The contact drying with a sudden change in pressure. 4.0. Molecular drying (sublimation drying of material): The mechanism and scheme of sublimation drying of material; Heat calculation of the basic apparatus of sublimation dryers; Vacuum dryers. 5.0. Drying in an electric field of high and super high frequency: Electricity consumption and the influence of humidity and frequency of electric field on intensity of drying with high frequency power; Drying generators with high frequency power and patterns of high-frequency dryers; Combined methods for drying of materials. 6.0. Drying in an acoustic (ultrasonic) field. 7.0. Drying process of osmosis. 8.0. Typical drying solutions in terms of construction and energy sources: Solar mobile dryers; Combined solar dryers; Solar systems, the Centers for drying; Farm (Park) of solar driers. 9.0. Testing of the mobile, universal, ecological, solar drying chamber module for drying of biological materials: Mobile, universal, ecological,cabinet solar dryer for drying of biological materials; Description of measurement installations; The experiment process and display measurement results. 10.0. Drying of fruits and vegetables using solar energy; Drying of fruits using solar energy; Drying vegetables using solar energy; Packaging and storage of dried fruits and vegetables.

practical teaching

Practical work: Calculation tasks and seminar papers from these theoretical wholes in the aim of sizing characteristic solutions of some of the studyed field area. Laboratory exercise: A study of drying material in thermoradial dryers. The aim of exercise is a study of the drying process characteristics and obtain the curve of drying and curve of drying speed. Seminary work from some of these theoretical wholes in order to introduce students to the existing solutions and their characteristics, and monitoring developments in the field.

prerequisite

Defined curriculum of study program / module

learning resources

Topic M. Radivoj, Basic calculations, designing and constructing of dryers, Scientific Book, Belgrade 1989., KPN; 2. Topic M. Radivoj, Design and construction of agricultural facilities (theory and laboratory exercises performed), Faculty of Mechanical Engineering, 1996. 3. Examples of computational tasks performed, PRA; 4. Topic M. Radivoj, Bogner Martin, Drying tehnics, Institute for publishing and teaching aids, Belgrade, 2002., KPN. 5. Topic M. Radivoj, Special techniques and technology of drying (printed materials for teaching, Handouts). Example of finished projects and term papers. Various guidelines and standards.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 0
laboratory exercises: 5
calculation tasks: 15
seminar works: 10
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 5
check and assessment of lab reports: 0
check and assessment of seminar works: 3
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 2
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 20
test/colloquium: 10
laboratory exercises: 0
calculation tasks: 10
seminar works: 30
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

Lebedev P.D., Heat exchangers, dryers and refrigerators, Publishing House, Moscow - Leningrad.
Lykov V. M. (1970), Dying in the chemical industry, the publishing house "Chemistry", Moscow.
Lebedev D.P., (1963), Calculation and design of the drying plants, State Energy Publishing House, Moscow - Leningrad.
Lebedev D. P., Shchukin AA, (1970), Thermal plants in industrial enterprises, "Energy" Moscow.
Lykov V. A, (1958), Heat and mass transfer in drying processes, State publishing house, Moscow.

Technological processes in agro complex

ID: MSc-0280
teaching professor: Вељић М. Милан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: agricultural engineering

goals

1. Obtaining knowledge through a multidisciplinary approach that can be considered rational, optimizing technical processes. 2. Mastery of processes in agricultural production through the knowledge of the type and condition of soil and agricultural materials. 3. Acquisition of practical skills for working in the field of new technologies in agriculture and in agricultural machinery.

learning outcomes

1. Opportunities for analysis and prediction of optimal solutions of agricultural technologies. 2. Control methods for the application of agricultural technology for the solution of agricultural machinery. 3. Application of knowledge through the acquisition and exploitation of agricultural machines. 4. Ability to communicate with users and producers. 5. Linking the field of agriculture and mechanical engineering.

theoretical teaching

1. Specificity of agricultural production. Dependence on technology from external influences. Planning performing certain operations. Power generating machinery in the agricultural technology. 2. Land. The mechanical physical properties, moisture, soil compaction and friction on the work surface. Land treatment. Requirements. Basic and additional processing. 3. Soil fertilization. The basic technology of fertilization, application of artificial fertilizers and manure. 4. Sowing and planting. Process technologies and solutions of sowing and planting. Agro-technical requirements. 5. Irrigation and chemical protection. Technological systems in the process of irrigation. The need for irrigation. Base and diversity of chemical protection. Technology and technical systems for pesticide use. 6. Arrangement of plants. The principles of arrangement of crops, harvesting and drying of forage crops. Technology and technical processes for harvesting crops. Technological scheme of combine harvesters. Harvest technologies of root and tubers crops. Harvesting fruit. Technological and technical systems for sorting vegetables.

practical teaching

1. Auditory exercises: Showing the determination of moisture agricultural materials-soil, plants and yields. Technological maps - making. Establishing criteria for the selection of agricultural requirements. The technological technical systems of tillage, fertilization, seeding, planting, watering and maintenance of the crops. 2. Laboratory Exercise: Determination of the coefficient of friction of soil on the desktop of agricultural machinery. 3. Production of the paper: Seminar on the protection of the soil, fertilization, irrigation, seeding and planting and sorting of agricultural crops. Consultations 4. Consultations are used to refer students in the preparation of the paper to help students in choosing literature and other consultations on teaching.

prerequisite

Enrolled VII semester students from Mechanical faculty and from FTN's,as well as students from the department of mechanization from PF Bgd. Novi Sad.

learning resources

1. M. Veljić Technological processes of mechanized agriculture, MF Belgrade, 1997.
2. Determining the coefficient of friction.
3. Lectures in electronic form.
4. Instructions for the preparation of the paper.
5. Renowned copy of the paper.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 15
laboratory exercises: 3
calculation tasks: 0
seminar works: 8
project design: 0
consultations: 2
discussion and workshop: 2
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 2
check and assessment of seminar works: 6
check and assessment of projects: 0
colloquium, with assessment: 2
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 20
laboratory exercises: 0
calculation tasks: 0
seminar works: 30
project design: 0
final exam: 40
requirements to take the exam (number of points): 50

references

Zivkovic D., Agricultural Technology, HTS Zrenjanin 2003.
Konstantinović J., Soil tillage in crop production, the Institute of Field Novi Sad, 1997.
Tesic M., Principle of operation of machines for harvesting grass material, FTN, 1984.
Various authors, Modern agricultural techniques in crop production, monographs, PF, Belgrade, 1997.

Technological processes in agro complex

ID: MSc-0560
teaching professor: Марковић Д. Драган
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: agricultural engineering

goals

1. Obtaining knowledge through a multidisciplinary approach that can be considered rational, optimizing technical processes. 2. Mastery of processes in agricultural production through the knowledge of the type and condition of soil and agricultural materials. 3. Acquisition of practical skills for working in the field of new technologies in agriculture and in agricultural machinery.

learning outcomes

1. Opportunities for analysis and prediction of optimal solutions of agricultural technologies. 2. Control methods for the application of agricultural technology for the solution of agricultural machinery. 3. Application of knowledge through the acquisition and exploitation of agricultural machines. 4. Ability to communicate with users and producers. 5. Linking the field of agriculture and mechanical engineering.

theoretical teaching

1. Specificity of agricultural production. Dependence on technology from external influences. Planning performing certain operations. Power generating machinery in the agricultural technology. 2. Land. The mechanical physical properties, moisture, soil compaction and friction on the work surface. Land treatment. Requirements. Basic and additional processing. 3. Soil fertilization. The basic technology of fertilization, application of artificial fertilizers and manure. 4. Sowing and planting. Process technologies and solutions of sowing and planting. Agro-technical requirements. 5. Irrigation and chemical protection. Technological systems in the process of irrigation. The need for irrigation. Base and diversity of chemical protection. Technology and technical systems for pesticide use. 6. Arrangement of plants. The principles of arrangement of crops, harvesting and drying of forage crops. Technology and technical processes for harvesting crops. Technological scheme of combine harvesters. Harvest technologies of root and tubers crops. Harvesting fruit. Technological and technical systems for sorting vegetables.

practical teaching

1. Auditory exercises: Showing the determination of moisture agricultural materials-soil, plants and yields. Technological maps - making. Establishing criteria for the selection of agricultural requirements. The technological technical systems of tillage, fertilization, seeding, planting, watering and maintenance of the crops. 2. Laboratory Exercise: Determination of the coefficient of friction of soil on the desktop of agricultural machinery. 3. Production of the paper: Seminar on the protection of the soil, fertilization, irrigation, seeding and planting and sorting of agricultural crops. Consultations 4. Consultations are used to refer students in the preparation of the paper to help students in choosing literature and other consultations on teaching.

prerequisite

VII semester from Mechanical faculty and from FTN's,as well students from the department of mechanization from Agriculture Faculty of BG or NS.

learning resources

1. M. Veljić Technological processes of mechanized agriculture, MF Belgrade, 1997.
2. Determining the coefficient of friction.
3. Lectures in electronic form.
4. Instructions for the preparation of the paper.
5. Renowned copy of the paper.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 15
laboratory exercises: 3
calculation tasks: 0
seminar works: 8
project design: 0
consultations: 2
discussion and workshop: 2
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 2
check and assessment of seminar works: 6
check and assessment of projects: 0
colloquium, with assessment: 2
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 20
laboratory exercises: 0
calculation tasks: 0
seminar works: 30
project design: 0
final exam: 40
requirements to take the exam (number of points): 50

references

Zivkovic D., Agricultural Technology, HTS Zrenjanin 2003.
Konstantinović J., Soil tillage in crop production, the Institute of Field Novi Sad, 1997.
Tesic M., Principle of operation of machines for harvesting grass material, FTN, 1984.
Various authors, Modern agricultural techniques in crop production, monographs, PF, Belgrade, 1997.

Tractors and self-propelled agricultural machines

ID: MSc-0298
teaching professor: Марковић Д. Драган
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: agricultural engineering

goals

1. Master the theoretical foundations of power machines-tractors and self-propelled agricultural machine-harvesters; 2. Conception and construction of farm tractors, small tractors and self-propelled chassis; 3. Transmission systems and for connecting the working machinery and mechanisms; 4. Concept of simultaneous transmission of power through the drive wheels and auxiliary shafts, energy balance, 5. The theory of operation, concept and design combines, budgets drive the moving parts and technological devices combine.

learning outcomes

1) Basic knowledge in theory work, the conception and construction of power machines-tractors, mowers and self propelled chassis and universal self-propelled combine, 2) Analysis of mechanical, hydrostatic transmissions and combined agricultural tractors, self propelled chassis and universal self-propelled combine harvesters, 3) Application computer facilities in the budgets and technological devices; 4) Linking the basic engineering knowledge and achieve synergy; 5) The acquisition of practical skills and application in practice.

theoretical teaching

1. Introduction, theory of operation, concept and construction of power machines-farm tractors, mowers and self propelled chassis; 2. Concepts of transmission and energy balance of simultaneous transmission of power through the drive wheels and auxiliary shaft; 3. Concepts, devices and systems for power and aggregate formation tractor-working agricultural machines; 4. Construction and theory of universal self-propelled combine harvesters, 5. Calculations of technological devices combine; 6. Concept drives the moving parts, hydrostatic power transmission components selection and calculation of hydrostatic drive moving parts and technological devices combine.

practical teaching

Laboratory exercises:
1. Practical introduction to technical solutions assemblies tractors, small tractors and self-propelled chassis;
2. Practical introduction to technical solutions and components and technological devices combine.
Computational tasks:
1. Development of arithmetic problems using computers and modern software packages in the field of tractors;
2. Development of arithmetic problems using computers and modern software packages in the field of universal self-propelled combine.
Development of the project:
1. Conceptual design of the tractor and operating self-propelled chassis;
2. Preliminary design in the field of universal self-propelled combine.

prerequisite

Attended courses of previous years of study and all the conditions defined curriculum of study program / module

learning resources

1.Novaković Vl.: Agricultural machinery 1, Belgrade;
2.Marković D.: Agricultural tractors, written lectures, Belgrade, 2006.;
3.Standardi and regulations for universal self-propelled tractors and combine harvesters.
4.Tractors and self-propelled agricultural machine-handouts.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 0
laboratory exercises: 5
calculation tasks: 5
seminar works: 0
project design: 20
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 2
check and assessment of lab reports: 1
check and assessment of seminar works: 0
check and assessment of projects: 7
colloquium, with assessment: 0
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 0
laboratory exercises: 10
calculation tasks: 10
seminar works: 0
project design: 40
final exam: 30
requirements to take the exam (number of points): 50

references

Martinov M., My tractor, Res trade, Novi Sad, 2007.
Zivanovic Z., N Janićijević., Automatic transmission vehicles, Belgrade, 2000.
Martinov M., Markovic D.: Machinery and tools for soil cultivation, the first part, FTN, 2002.;
Gligoric R., Mechanisms of agricultural machinery-with the settlement tasks, PF, Novi Sad, 2005.
Veselinov B., M Martinov., Bojic S., Machinery for biosystems, practical, FTN Novi Sad, 2009.

control engineering

Adaptive systems
Automatic Control
Automatic Control
Automatic Control Systems
Automation Systems Programming
bioaumatics
Biomedical optoengineering
Biomedical photonics
Biosystem stochastic identification
Computer control
CONTROL COMPUTERS AND AUTOMATION
Control Systems Technology
Dynamic Systems Simulation and Testing
Early diagnostics of cancer and melanoma
Fractal mechanics
Fuzzy Control Systems
Fuzzy Control Systems
Industral Automation
Informational Technologies in Medicine
Intelligent Buildings
Intelligent Control Systems
Introduction to nanosystems
Linear stochastic systems
Linear System Design
Nanomedical Engineering
Nanotechnology
Neural networks and fuzzy logic
neural networs and fuzzy logic
Nonlinear Systems 1
Nonlinear Systems 1
Nonlinear Systems 2
Nonlinear Systems 2
Process identification
Process identification
Professional practice M - CS
professional practice m -SAU
Project documentation
Signal Processing
Spectroscopy methods and techniques
Stochastic Linear Systems
Student practice M - BME
Object and process dynamics

Adaptive systems

ID: MSc-0586
teaching professor: Бучевац М. Зоран
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: control engineering

goals

• Introducing with: concept of adaptive control and different types of adaptive control systems-ACS.
• Mastering with: different methods for synthesis of adaptive control systems.
• Mastering of working with physical adaptive control systems.

learning outcomes

• Acquiring the knowledge needed to properly understand the concept of adaptive control and various types of ACS.
• Easier handling with digital computers in both hardware and software sense, as part of ACS.
• Using the methods needed for analysis and synthesis of different adaptive control systems.
• To apply computer to solve problems of computational nature in "off line" mode, either related to analysis or synthesis of ACS.
• Analysis and design of real physical ACS.

theoretical teaching

AT
• Introductory considerations: definitions of adaptive control systems and algorithms; parameters identification and estimate of the process state; state of the ACS synthesis problem
• Types of adaptive systems: ACS with gain scheduling; model reference ACS (MRAS); ACS with self tuning regulators (STR); stochastic ACS; self-oscillating ACS
• ACS with gain scheduling: linearization of static characteristics; linearization of CS by means of nonlinear feedback dynamic regulator; linearization by means of sampling period varying
• Model reference ACS (MRAS): problem of synthesis of MRAS; gradient approach; synthesis by Lyapunov's method, synthesis by the theory of passivity: model in deviation and deviation variation; stability theorem
• ACS with self tuning regulators (STR): indirect STR, application of direct STR, direct STR algorithm, special cases of direct STR, deterministic direct algorithm; minimum variance direct STR; LS(least square)-based indirect STR synthesis
• Real time estimation: real time parameters estimation: LS and regression models; recursive procedure; time continuous estimation; estimation with continuous excitation; system classes that LS can be applied on
• Auto-tuning of regulator parameters: empirical procedures based on step response and frequency characteristic; сопствене oscillations of relay CS
• Synthesis ACS based on variable structure systems (VSS): adaptation of the sliding mode parameter; algorithm; technical realization
• Synthesis of technological process ACS based on VSS: problem statement and the adaptive algorithm synthesis; stability and convergence of the algorithm; process identification
• Adaptive control of milling: milling model; optimization; control synthesis

practical teaching

PA+PL+PZ

• PA1-PA10 Direct tracking of the course theory through the illustrative examples
• PL1-PL7 Direct tracking of the course theory thorugh doing the laboratory exercises by means of control computers and physical ACS
• PZ1-PZ3 Making of all-inclusive computational assignments

prerequisite

• Knowledge of both continuous and discrete control systems theory.
• Knowledge of hardware and software of digital computers.

learning resources

• Manuscript at http://au.mas.bg.ac.rs/Nastava-Kau/Nastava_Download.htm
• Lj. S. Draganović, Adaptiv control systems (in serbian), Svjetlost, Sarajevo, 1982.
• Digital computer; Physical ACS

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 20

active teaching (practical)

auditory exercises: 21
laboratory exercises: 16
calculation tasks: 3
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 3
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 3
test, with assessment: 4
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 45
laboratory exercises: 20
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

K. J. Astrom, B. Wittenmark, Adaptive Control, Addison-Wesley, New York, 1989.
Lj. S. Draganović, Adaptiv control systems (in serbian), Svjetlost, Sarajevo, 1982.
S. K. Narendra, R. V. Monopoli, Application in Adaptive Control, Academic Press, New York, 1980.
K. J. Astrom, B. Wittenmark, Computer-Controlled Systems, Prentice-Hall, N.J., 1990.
D. Y. Landau, Adaptive Control: The Model Reference Approach, Marcel Dekker, New York, 1979.

Automatic Control

ID: MSc-0566
teaching professor: Ристановић Р. Милан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: control engineering

goals

Acquisition of knowledge from the theory of linear control systems.

learning outcomes

Acquiring the knowledge obtained is used in engineering practice and the basis for monitoring the course of nonlinear systems and advanced courses of synthesis of linear systems.

theoretical teaching

P, PI and PID control. Tuning of PID controller. Analysis of system in system state. Phase portrait. Lyapunov concept of stability. Characteristics of the system stability. The concept of controllability and observability. General Algebraic stability criteria and frequency.

practical teaching

The analysis using software tools MATLAB and Simulink. Experimental determination of the system transfer function. Experimental setup of the regulator.

prerequisite

Basic automatic control knowledge.

learning resources

Computer laboratory. Programming package MATLAB and Simulink. Laboratory

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 15
laboratory exercises: 10
calculation tasks: 5
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 5
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 6
test, with assessment: 0
final exam: 4

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 45
laboratory exercises: 5
calculation tasks: 15
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 50

references

М. Ристановић, Automatsko upravljanjel, printed lectures
B. Milojkovic, Lj. Grujic, Automatsko uprvavljanje, Mechanical Engineering Faculty, Belgrade, 1980.
M. Stojic, Kontinualni sistemi automatskog upravljanja, Nauka, Beograd, 1988.
Karl Johan Aström, Richard M. Murray, Feedback Systems, PRINCETON UNIVERSITY PRESS, New Jersey, 2008.
Stephen Boyd, Craig Barratt, Linear Controller Design: Limits of Performance, Prentice-Hall, 1991.

Automatic Control

ID: MSc-0286
teaching professor: Лазић В. Драган
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: control engineering

goals

• to provide theoretical basis, proofs of theorems and more detailed definitions than in the basic course (Introduction of Automatic Control) to get students familiar with the area and therefore fully understand the essence of matter.
• to include all the issues which usually listens worldwide at a course of control
• to enable students to follow the following subjects in this Department

learning outcomes

• The acquisition of wider knowledge of the automatic control, as a technical field that requires a modern engineer
• identify and use the methods needed for analysis and synthesis of controllers in the control systems, and the entire control systems
• the implementation of computers and MATLAB and address the underlying problems of the automatic control, as well as other engineering problems
• the analytical and / or experimental investigation of the basic dynamic and static characteristics of the systems

theoretical teaching

The concept of state space. Linear and nonlinear systems, time invariant and time varying systems. Definition of mathematical models in total coordinates and the coordinates of the absolute deviations. Defining the mathematical model in state space, relationship with differential equation and the transfer matrix of the system. Algorithms for the transition from one form of mathematical model to another. Lyapunov's concept of stability. Different properties of stability of the zero steady state: stability, attraction, asymptotic stability. Different characteristics of system stability: stability, border of stability and unstability. The concept of controllability and observability. Logarithmic frequency response and Bode diagrams. Algebraic stability criteria and frequency stability criteria: Hurwitz, Nyquist, Bode, Cipkin, Mihailov.

practical teaching

Practical training shall include the computational tasks which illustrates the exposed material given by the definitions or by any theorem. Connecting different types of mathematical models of linear systems: differential equations, equations of the state and the output equations, transfer functions and block diagram of the system - the transition from one form to another model. Simulation results for the illustration the above definitions and theorems are done on personal computers using MATLAB. In this subject much more tools, commands, scripts, ... from MATLAB will be used, as compared to those obtained in the subject Introduction of Automatic Control.

prerequisite

Passed course Introduction of Automatic Control and nothing more

learning resources

• Script on website: http://au.mas.bg.ac.rs/Nastava-Kau/Nastava_Download.htm
• Licensed Software in the possession of the Faculties.
• Freeware software.
• PCs.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 12
laboratory exercises: 18
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 4
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 6
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 50
laboratory exercises: 5
calculation tasks: 10
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

Ljubomir Grujic, Dragan Lazic, "AUTOMATIC CONTROL", Script, Faculty of Mechanical Eng., 2007

Automatic Control Systems

ID: MSc-0352
teaching professor: Лазић В. Драган
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: control engineering

goals

• to provide theoretical basis, proofs of theorems and more detailed definitions than in the basic course (Introduction of Automatic Control) to get students familiar with the area and therefore fully understand the essence of matter.
• to include all the issues which usually listens worldwide at a course of control
• to enable students to follow the following subjects in this Department

learning outcomes

• The acquisition of wider knowledge of the automatic control, as a technical field that requires a modern engineer
• identify and use the methods needed for analysis and synthesis of controllers in the control systems, and the entire control systems
• the implementation of computers and MATLAB and address the underlying problems of the automatic control, as well as other engineering problems
• the analytical and / or experimental investigation of the basic dynamic and static characteristics of the systems

theoretical teaching

The concept of state space. Linear and nonlinear systems, time invariant and time varying systems. Definition of mathematical models in total coordinates and the coordinates of the absolute deviations. Defining the mathematical model in state space, relationship with differential equation and the transfer matrix of the system. Algorithms for the transition from one form of mathematical model to another. Lyapunov's concept of stability. Different properties of stability of the zero steady state: stability, attraction, asymptotic stability. Different characteristics of system stability: stability, border of stability and unstability. The concept of controllability and observability. Logarithmic frequency response and Bode diagrams. Algebraic stability criteria and frequency stability criteria: Hurwitz, Nyquist, Bode, Cipkin, Mihailov.

practical teaching

Practical training shall include the computational tasks which illustrates the exposed material given by the definitions or by any theorem. Connecting different types of mathematical models of linear systems: differential equations, equations of the state and the output equations, transfer functions and block diagram of the system - the transition from one form to another model. Simulation results for the illustration the above definitions and theorems are done on personal computers using MATLAB. In this subject much more tools, commands, scripts, ... from MATLAB will be used, as compared to those obtained in the subject Introduction of Automatic Control.

prerequisite

Passed course Introduction of Automatic Control and nothing more

learning resources

• Script on website: http://au.mas.bg.ac.rs/Nastava-Kau/Nastava_Download.htm
• Licensed Software in the possession of the Faculties.
• Freeware software.
• PCs.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 12
laboratory exercises: 18
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 4
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 6
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 50
laboratory exercises: 5
calculation tasks: 10
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

Ljubomir Grujic, Dragan Lazic, "AUTOMATIC CONTROL", Script, Faculty of Mechanical Eng., 2007

Automation Systems Programming

ID: MSc-0277
teaching professor: Рибар Б. Зоран
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: control engineering

goals

-This subject introduce candidate with the basic applications of digital computers in automatic control.
-Candidate will be familiar with basic statements of programming language C and programming package MATLAB.
-Candidate will be able to make control software in programming language C.
-This subject introduce candidate with the basic knowledge of programming package MATLAB and its applications in automatic control.

learning outcomes

-Acquiring basic knowledge in programming language C.
-Acquiring basic knowledge in programming package MATLAB.
-Introducing and use methods for analysis and synthesis of control systems by mentioned programming packages.

theoretical teaching

Personal computers in automatic control. Computer communications with peripheral devices. Basic functions of programming language C. main() function. Basic functions for communication with peripheral devices printf() and scanf(). Constants, variables and expressions. Preprocessor statements. Data types. Variables address. Pointers. Dereferencing of pointers. Program branching statements: conditional branching, comparison of expressions, statements if..else, switch, do...while. Structures and unions.
Variables,matrices and vectors in MATLAB. Manipulations of vectors and matrices. Vectors and matrices operations. Input and output files. Use of strings. While loop.Conditional branching if statement. Break and continue statement. Multiple branching, switch statement. Functional file. Return value of function. Inline statement. Function of function. Creating graphics. Graphical processing of the pictures. S-functions and simulation diagrams.

practical teaching

Examples are in coordinatin with theory: making programs in programming language C and in MATLAB. Examples are from automatic control practice. Realization of various control algorithms, acquisition of data from various peripheral devices.Application of PC computer as digital controller. Control toolbox of programming package MATLAB,and its application in solving various tasks from automatic control. Training is realized in computer laboratory with experimental proof.

prerequisite

Defined by curriculum of study program.

learning resources

Hands out on: http://au.mas.bg.ac.yu/Nastava-Kau/Nastava_Download.htm

•Freeware и Shareware software, Faculty of Mechanical Engineering Belgrade.

•PC computers, Computer laboratory, Faculty of Mechanical Engineering Belgrade

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 0
laboratory exercises: 30
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 10
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 60
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

Hands out on: http://au.mas.bg.ac.yu/Nastava-Kau/Nastava_Download.htm

bioaumatics

ID: MSc-0676
teaching professor: Рибар Н. Срђан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: control engineering

goals

Introduce students to the fundamental principles of regulatory processes and adaptation in biological systems. Mathematical modeling of regulatory processes, biological data acquisition system in order to confirm the experimental results, the possibility of application in medicine and technology. Cooperation with experts from the fields of medicine, automation

learning outcomes

Students acquire the ability to analyze issues related to the field of bioregulation mechanism, the formation of mathematical models of biological systems using contemporary analytical methods, procedures, techniques, and computer equipment. Students are trained to master the synthesis of knowledge of anatomy, physiology, automatic control and signal processing in order to achieve accurate models of biological systems.

theoretical teaching

Introduction to the bioautomatics, a division of the system, the biosphere. Wildlife, organizing systems, adaptation and regulation. Functional parts of the human body, cells and cell function. Proteins as building blocks of living systems, amino acids, nucleic acids. Tubulin protein structure, function, microtubules, centiole, regulatory processes in the cell. DNA, RNA, regulation and adaptation at the cellular level. Senses as sensors, types, roles. Eyesight, function, defining subsystems and interactions with the environment. Sensors in robotics, advanced sensor technology.

practical teaching

Mathematical modeling of the system, examples. Mathematical modeling of animal world system. Mathematical modeling of subsystems in the human body, the mathematical model of the cell. Mathematical modeling of the dynamic and static properties of amino acids and proteins, primary and secondary structure of proteins. Work on STM / AFM device, visualization of protein structures. Mathematical modeling of the dynamic characteristics and regulatory processes of microtubules and centrioles. Mathematical modeling of DNA regulatory processes. Work on STM / AFM device visualization DNA of the cell. Mathematical modeling of the senses. Mathematical modeling of sight, vision sensors. Mathematical modeling of 3D images, 3D image acquisition. Acquisition of data from sensors and processing.

prerequisite

learning resources

1. Written material from the lecture (handouts)
2. Matlab, Mathematics and appropriate software tool
3. Material for exercises in electronic form available on the website

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 35

active teaching (practical)

auditory exercises: 10
laboratory exercises: 2
calculation tasks: 4
seminar works: 1
project design: 10
consultations: 1
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 5
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 4
test, with assessment: 0
final exam: 3

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 50
laboratory exercises: 30
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 10
requirements to take the exam (number of points): 40

references

Written material from the lecture (handouts)
Matlab, Mathematics and appropriate software tool
Material for exercises in electronic form available on the website

Biomedical optoengineering

ID: MSc-0606
teaching professor: Коруга Љ. Ђуро
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 4
final exam: written
parent department: control engineering

goals

To familiarize students with materials for contact lenses and optical designs: spherical, aspherical, toric, progressive, progressive-toric, as well as production technology of contact lenses: cutting, polishing, final control, hydration, sterilization and characterization. To understand the operating principles of lasers and LEDs. To get more familiar with the application of lasers in ophthalmology.

learning outcomes

Mastering the skills of optoengineering a student acquires the ability to design the device. The student is qualified to participate in the design and manufacture of contact lenses and optical and optoelectronic instrument for identifying and measuring the reflection, absorption, scattering and emission of light. The student will have more knowledge regarding the principle of lasers work and their application in ophthalmology.

theoretical teaching

Electromagnetic nature of light; Photometry; Optical materials - biocompatibility; Technology of optical devices, contact lenses and eyeglass lenses; Methods of characterization of optical materials; Optical devices in ophthalmology (keratometry, topography, refractometry, tonometry, tomography); Quantum Mechanics; Atomic Physics; Lasers (operating principles and types of lasers); Laser application in medicine; Laser application in ophthalmology (Excimer Laser - refractive surgery); Surgery keratoconus; Ultrasound; Application of ultrasound in medicine; Application of ultrasound in ophthalmology (cataract surgery);

practical teaching

Servicing of apparatus and devices for ophthalmic diagnosis. The production technology of contact and intraocular lenses. Technology of manufacturing eyeglass lenses and their characterization. Practical work in the production of contact lenses (Optix-Zemun). Practical work in surgical hall (LaserFokus). Practical work in optical laboratories (Nanolab MF, Institute of Physics).

prerequisite

Enrolled in the third semester of Master studies on the module Biomedical Engineering and passed the examination of biomedical photonics

learning resources

1. Performed with written lessons (handouts), 2. Web's of ophthalmology, 3. Materials of Laserfocus and Optix company, where the students have a part of practical training

number of hours

total number of hours: 45

active teaching (theoretical)

lectures: 25

active teaching (practical)

auditory exercises: 8
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 6
check and assessment of projects: 0
colloquium, with assessment: 3
test, with assessment: 0
final exam: 3

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 45
laboratory exercises: 0
calculation tasks: 0
seminar works: 15
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

Jan Tuner, Lars Hode: Laser Therapy, Prima Books, 2005.
Krešmir Čupak: Fotokoagulacija - Laser u oftalmologiji, Zrinski, 1979.
Darko Vasiljević: Optički uređaji i optoelektronika, Book, 2005.
Aleksandar Parunović, Dobrosav Cvetković: Korekcija refraktivnih anomalija oka, Zavod za udžbenike i nastavna sredstva, Beograd, 2005.
Vasilije R. Misita: Dijabetička retinopatija (lečenje laserfotokoagulacijom), Zavod za udžbenike i nastavna sredstva, Beograd, 2000.

Biomedical photonics

ID: MSc-0659
teaching professor: Коруга Љ. Ђуро
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 4
final exam: written
parent department: control engineering

goals

That students learn the structure and working principle of an eye, and its properties using knowledge of biomechanics and the theory of light. To acquire knowledge concerning polarization, interference and diffraction of light on the example of the eye. To learn to measure visual acuity, objective and subjective determination of diopter. To get acquainted with the principles of refractive surgery, to acquire knowledge concerning changes the curvature of the cornea and corneal turning power, and to become familiar with the production and incorporation of artificial intraocular lenses.

learning outcomes

Mastering the knowledge gained from biofotonike, student gain ability to understand the basic laws of functioning of the eye, that is required for lens design and participation in technical assistance to a doctor at a clinic during diagnosis. The student is able to understand the function of the contact lens and optical and optoelectronic instrument for identifying and measuring the reflection, absorption, scattering and light emission of biomolecules and tissue.

theoretical teaching

Geometric optics (basic concepts and laws); Wave optics (interference, polarization, diffraction); Optical systems; The theories upon aberrations (the quality of optical systems); Optical measurements; Anatomy, physiology and histology of the eye; Eye as an optical system; Structure and function of the retina; The notion of accommodation; Visual acuity; Visual perception (connection eye - brain); Binocular vision; Eye-movements; Color vision; Refractive anomalies of the eye (nearsightedness, farsightedness, astigmatism, presbyopia); Objective and subjective measurements of refraction (measurement of visual acuity); Correction of refractive anomalies of the eye; Glasses and contact lenses; Bad eyesight; Eye surgery.

practical teaching

Auditory exercises that allow the mastering of basic relations and formulas in optics; Dealing with the essential components of the optical system; Insight and introduction to the working principle of the device during ophthalmologic examination.

prerequisite

Enrolled in the first semester of Master studies on the module Biomedical Engineering

learning resources

1. Performed with written lessons (handouts), 2. Web's of ophthalmology, 3. Materials of companys Laserfocus and Optix, where the students have a part of their practical training

number of hours

total number of hours: 45

active teaching (theoretical)

lectures: 24

active teaching (practical)

auditory exercises: 0
laboratory exercises: 9
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 6
check and assessment of projects: 0
colloquium, with assessment: 3
test, with assessment: 0
final exam: 3

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 45
laboratory exercises: 0
calculation tasks: 0
seminar works: 15
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

Michaels, D.D. Visual Optics and refraction, Grafomark, Beograd, 2000.
Milojević Aleksandar: Talasna optika, Beograd, 1970.
Dr. Ljubiša Nikolić: Hirurgija katarakte, Zavod za udžbenike, Beograd, 2009.
Aleksandar Perunović: Upoznajte svoje oči, Zavod za udžbenike i nastavna sredstva, Beograd, 1997.
David A. Atchison: Optics of the human eye, Elsevier Health Sciences, April 2000.

Biosystem stochastic identification

ID: MSc-0683
teaching professor: Дебељковић Љ. Драгутин
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 2
final exam: written+oral
parent department: control engineering

goals

To meet some classes of bio-systems. To be familiar with the knowledge of stochastic, ergodic random processes and with the methods for control system analysis and design in time and frequency domain.Student should be familiar with the basic ideas from identification and estimation theory, in order to be able to make a reconstruction of process model, based only on input - output measurements data collected over some period of time. In that sense it is expected to recognize process structure, order of process model and to estimate unknown parameters of process.

learning outcomes

To be familiar, to introduce as well basic principle of contemporary probability theory and mathematical statistics and all of that to implement to linear continuous time invariant automatic control systems, when they are subjected to the influence of random signals. Contemporary methods of identification enables one to form mathematical models of different processes with much more accuracy than only based on analytical approach.Moreover this procedure, when the real time control is used, enables so called adaptive control, which can perform all desire process characteristics and achieve practically all severe demands which, today, can be very often contradictory.

theoretical teaching

Introduction. Some notes about bio-systems
Mathematical modeling of bio-systems.
Random variables and stochastic processes
Deterministic systems subjected to the influence of random inputs
Stochastic systems subjected to the influence of random inputs
Linear systems response
Mean square error analysis
Mathematical model of processes: Analytical and experimental approach
Need for identification and estimation.
Conventional identification methods
Estimation theory
Least square method
Some other methods. When and why?

practical teaching

Mathematical model of processes: Analytical and experimental approach
Mean square error analysis
Conventional identification methods

prerequisite

Given exams from subjects : Automatic Control.

learning resources

D. Lj. Debeljkovic, Analysis, Synthesis and Estimation of Linear Control Systems in the Presence of Random Signals, Faculty of Mechanical Engineering, Belgrade, 2010 (in Serbian), pp. 444, ISBN 978 – 86 – 7083 – 683 – 9.

D. Lj. Debeljkovic, Identification of dynamical processes with lumped and distributed parameters, Faculty of Mechanical engineering, Belgrade 2010.

Handouts

number of hours

total number of hours: 30

active teaching (theoretical)

lectures: 20

active teaching (practical)

auditory exercises: 2
laboratory exercises: 2
calculation tasks: 0
seminar works: 2
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 2
check and assessment of seminar works: 2
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 0
final exam: 0

assessment of knowledge (maximum number of points - 100)

feedback during course study: 30
test/colloquium: 20
laboratory exercises: 0
calculation tasks: 0
seminar works: 20
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

D. Lj. Debeljkovic, Analysis, Synthesis and Estimation of Linear Control Systems in the Presence of Random Signals, Faculty of Mechanical Engineering, Belgrade, 2010 (in Serbian), pp. 444,
D. Lj. Debeljkovic, Identification of dynamical processes with lumped and distributed parameters, Faculty of Mechanical engineering, Belgrade 2010.

Computer control

ID: MSc-0631
teaching professor: Бучевац М. Зоран
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: control engineering

goals

•Introducing of: nature of computer control systems-CCS related to types of signal transfer; real CCS as mainly presented in the practice; choice of physical model of CCS; mathematical modeling of CCS.
•Mastering of: methods of determining of static and dynamic characteristics of CCS; real time computer control by discrete algorithms.
•Off line use of MATLAB - but as software standard of automatic control.

learning outcomes

•Exact but not approximate treatment of CCS according to their nature.
•Scientific and engineering treatment of CCS as dominantly represented in practice.
•Applying the methods of analysis and synthesis of controller in CCS, as well of whole CCS.
•Solving problems of calculation nature by means of computer and MATLAB in the "off line" mode, related to the analysis or synthesis of CCS.
•Determining of dynamic and static characteristics of CCS.

theoretical teaching

•Introduction in Computer Control-CC: specific nature of CCS, importance and examples
•Samplers, quantization and coding: real and ideal samplers, mathematical description, technical realization; description of quantization and coding
•Complex and frequency images of ideal sampler output: determination; Shannon's theorem
•CCS transfer characteristics: definition in the frequency and s-domain
•Systems for signal duration extension: definition, analysis and transfer characteristics
•Z-transform: definition,transfer characteristics in z-domain
•Block digrams of CCS: algebra of s and z block diagrams
•Modeling and analysis of CCS: classical mathematical modeling, static characteristics and types of action
•State concept of CCS: modern mathematical modeling, properties and solving
•Dynamic properties of CCS: definitions, determining, criteria

practical teaching

PA:

Examples, determining:
•graphically, of signal in receiver; of physical real CCS
•analytically, $x^*(t)$; of quantization and coding
•$X^*(s)$ and $X^*(j\omega)$; application of Shannon's theorem
•of discrete transfer characteristics
•transfer characteristics of holds and analysis
•of z-images; of originals
Examples:
•applying of z-block algebra;

•discretization of differential behavior equation; determining of discrete state and output equations; determining of motion and response
•testing of controllability, observability, stability

PL:

Determining in MATLAB:
•Simulation of different types of signal transfer
•X*(s) and X*(jω)
•hold characteristics
•z-images, originals
•discrete mathematical models
•dynamical properties
•sampler output response at oscilloscope
•CC of physical object in real time

PZ:

•Manipulation with mathematical models, determining of static and dynamic characteristics

prerequisite

• Basic knowledge of automatic control.
• Basic computer knowledge based on use of PC.
• Basic knowledge of undergraduate mathematics.

learning resources

1.Manuscript at http://au.mas.bg.ac.rs/Nastava-Kau/Nastava_Download.htm, DVL
2.Ljubomir Grujić: Discrete systems (in Serbian), Mechanical engineering faculty, Belgrade 1991, KDA, library and bookstore of MEFB
3.Power supply, function generator, oscilloscope, lab. for Digital control systems, EOP/LEO
4.Protoboards, integrated circuits, ADDA electronic card, Lab. for Digital control systems, EOP/LEO
5.Object of control, Lab. for Digital control systems, EOP/LPI
6.Licensed and freeware software, MEFB
6.PCs, Lab. for Digital control systems and computer lab. MEFB

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 16
laboratory exercises: 13
calculation tasks: 1
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0

research: 0

knowledge checks

check and assessment of calculation tasks: 1
check and assessment of lab reports: 2
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 5
test, with assessment: 2
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 45
laboratory exercises: 10
calculation tasks: 10
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

Ljubomir Grujić: Discrete systems (in Serbian), Mechanical engineering faculty, Belgrade 1991, KDA, library and bookstore of MEFB
Benjamin C. Kuo, Digital control systems, Holt Rinehart and Winston, Inc., New York, 1980., KSJ, available in library of MEFB
H. F. Vanlandingham, Introduction to digital control systems, Macmillan Publishing Company, New York, 1985.
C. H. Houpis, G. B. Lamont, Digital control systems, McGraw-Hill, New York, 1985.
J. R. Leigh, Applied digital Control, theory, design and implementation, Prentice-Hall, Englewood Cliffs, New Jersey, 1985.

CONTROL COMPUTERS AND AUTOMATION

ID: MSc-0387
teaching professor: Бучевац М. Зоран
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: control engineering

goals

• Introducing with: types of control by digital computer, just control computer as well its interfaces and transducers.
• Mastering of: both classical automation by means od finite automata so and modern by means of PLCs.
• Mastering of control both mashines and equipments so and processes in real time, even by use advanced width modulation.

learning outcomes

• Knowledge needed for the proper handling of the control computers and related accessories.
• Using of the methods for analysis and synthesis of combinational and sequential finite automata for the classical automation.
• Using PLCs for automation.
• To apply computer for control in real time with using the most sophisticated control algorithms.

theoretical teaching

AT
• Introduction to control computers and automation: types of control by means of digital computer; definition of process computer; definition of automation; control computer, automatic control and automation
• Control computer: structure of control computer; instructions and data; input output communications; higher programming languages
виши програмски језици
• Interfaces of control computer: control computer architecture; logic inputs and outputs; A/D and D/A conversion; alphanumeric inputs and outputs; interrupts
• Sensors for control computer: introduction on sensors; position sensors, velocity and acceleration; force sensors; temperature sensors; strain gages; optical sensors
• Classical automation by means of finite automata: combinational and sequential finite automata; input-information circuit; control-processing circuit; output-energetic circuit; Hoffman's method
• Programmable logic controller-PLC: PLC architecture; inputs and outputs; input output equipments
• PLC programming: hardware versus software logic; programming languages: ladder diagrams, functional blocks and higher programming languages; programming, visualization, diagnostic, documenting, choice of PLC
• Control of machines and equipments: interpolations; point to point motion; contour motion; positioning by means of step motor
• Process control: real time control; control algorithms; output transducers and actuators; hardware and software adjustment
• Pulse width modulated control: mathematical description; control algorithms; stability

practical teaching

PA+PL+PZ
• PA1-PA11 Direct tracking of the course theory through the illustrative examples
• PL1-PL10 Direct tracking of the course theory thorugh doing the laboratory exercises by means of control computers, PLCs, integrated digital circuits and transducers
• PZ1 Making of all-inclusive computational assignment

prerequisite

• Basic knowledge of computer.
• Basic knowledge of programming and programming languages.

learning resources

• Manuscript at http://au.mas.bg.ac.rs/Nastava-Kau/Nastava_Download.htm
• Zoran Bučevac: Laboratory exercises for digital systems, Mechanical engineering faculty, Belgrade 2011, PRA, library and bookstore of MEFB
• Integrated digital circuits; Oscilloscope; Control computer; PLC; Transducers

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 20

active teaching (practical)

auditory exercises: 21
laboratory exercises: 18
calculation tasks: 1
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 1
check and assessment of lab reports: 1
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 5
test, with assessment: 3
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 45
laboratory exercises: 5
calculation tasks: 15
seminar works: 0
project design: 0

final exam: 30
requirements to take the exam (number of points): 30

references

J. Bollinger, N. Duffie, Computer Control of Machines and Processes, Addison-Wesley, New York, 1988.
C. T. Jones, L. A. Bryan, Programmable controlers, IPC/ASTEC Publication, Atlanta, 1983.
R. J. Bibbero, Microprocessors in industrial control, Instrument Society of America, N.C., 1982.
C. D. Jonson, Microprocessors-Based Process Control, Prentice-Hall, N.J., 1984.
Y. Koren, Computer Control of Manufacturing Systems, McGraw-Hill, New York, 1983.

Control Systems Technology

ID: MSc-0118
teaching professor: Рибар Б. Зоран
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: control engineering

goals

-This subject introduce candidate with detailed characteristics of computer controlled systems.Also the candidate will be educated to implement knowledge to real computer controlled systems.
-Candidate will be familiar with some metodologies for selection of computer components as well as other control components.
-Candidate will be familiar with mentioned control systems.

learning outcomes

-To acquire basic knowledge from control systems theory and practice as well as other fields of applied sciences.
-Introduction with methods for dynamic analysis and synthesis of control systems.
-Methodology of analytical and/or experimental determination of static and dynamic characteristics of control systems.

theoretical teaching

Introduction in computer controlled systems with examples from practice. Electropneumatic servovalves. Electropneumatic servosystems. Electrohydraulic proportional valves. Pressure regulators with proportional valve. Electroohydraulic servovalves. Electrohydraulic servosystems with linear and rotational motion. Industry control computers. Programabile logic controllers with associate modules.
Industrial computer networks. Synhronuos and asynhronuos networks. Industrial computer networks topology. Industrial networks components. Redundant control systems. Computer redundancy and measuring system redundancy.

practical teaching

Electropneumatic servovalves. Electrohydraulic proportional valves. Pressure regulators with proportional valves. Electropneumatic sevovalves. Electrohydraulic servosystems with rotational and linear motion.Industrial computers. Programabile logic controllers. Industrial computer networks. Synchronous and asynchronous computer networks. Computer networks topology. Industrial network components. Redundat control systems.

Practice with pneumatic valves, electrohydraulic servovalves as well as electrohydraulic servosystems. Practice with industrial computers and networking.

prerequisite

Defined by curriculum of study program.

learning resources

-Control systems technology hands-out on: http://au.mas.bg.ac.yu/Nastava-

Kau/Nastava_Download.html

-Electrohydraulic servosystem, Control systems laboratory.

-Electropneumatic servosystem, Control systems laboratory.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 15
laboratory exercises: 15
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 4
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 6
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 40
laboratory exercises: 20
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

Pneumoelectric Control Systems Z.Ribar. Faculty of mechanical Engineering. 1997.
HydraulicControl Systems. H.E.Merritt. 1967.
The Analysis and Design of Pneumatic Systems. B.Andersen.1967.

Dynamic Systems Simulation and Testing

ID: MSc-0563
teaching professor: Рибар Б. Зоран
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: control engineering

goals

This subject introduce candidate in Matlab Simulink simulation package.
This subject introduce candidate with examination of static and dynamic characteristics of automatic control systems.
Candidate will be familiar with identification of dynamic systems.

learning outcomes

Introduction in experimental determination of static and dynamic characteristics of automatic control systems.
Introduction in presentation of various automatic control systems and control systems using program package for simulation of dynamic systems.
Introduction for verification used mathematical models of dynamic systems by experiment and by use of program package Simulink.

theoretical teaching

Program package Simulink. Approximate Methods for solving differential equations. Simulation of time continuous and time discrete automatic control systems. Simulation of hybrid automatic control systems. Basic elements of program package Simulink necessary for simulation of dynamic systems. Mathematics models of dynamic systems.
Representation of these models using of programe package Simulink. Verification of the results of simulation. Simulation of linear controllers. Simulation of nonconventional controllers such as variable structure, tracking, fuzzy etc. Step function responses of dynamic systems. Examination of automatic control systems using sinusoidal function. Determination of frequency characteristics. Basic methods for identification of mathematics models of plants by Simulink.

practical teaching

Introduction with methods for approximate solving differential equations by use Simulink. Difference equations solving. Discretized systems simulations in Z domain. basic elements of program package Simulink. Modelling of static systems. Modelling of dynamic systems. Presentation of simulation data. Simulation of continuous automatic control systems. Simulation of discrete systems of automatic control. Simulation of hybrid systems of automatic control. Conventional control algorithms. Nonconventional control algorithms. Identification of mathematical models of dynamic systems.

prerequisite

Defined by curriculum of study program.

learning resources

-Dynamic Systems Simulation and Testing hands-out on: http://au.mas.bg.ac.yu/Nastava-

Kau/Nastava_Download.html

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 15
laboratory exercises: 15
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 5
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 5
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 30
laboratory exercises: 30
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

Early diagnostics of cancer and melanoma

ID: MSc-0564
teaching professor: Коруга Љ. Ђуро
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: control engineering

goals

The goal of this course is to introduce molecular mechanisms of developing cancer and existing methods for early diagnostics. Through critical approach to existing methods, and mastering the latest noninvasive or minimally invasive methods for early detection of cancer and melanoma, student is given basis for inclusion in modern scientific research and development of new diagnostic methods, as well as application and improvement of existing methods in biomedical practice.

learning outcomes

Student is familiar with molecular, genetic, and biochemical basis of cancer development, influential factors for pathogenesis and development of cancer. Student has mastered structural, energetic and bioinformational characteristics of pathogenesis of different types of cancer and tumor (skin cancer, melanoma, cervical cancer, oral cavity cancer, colorectal cancer, breast cancer, and brain tumor) and is familiar with existing diagnostic methods and challenges for improving specificity and sensitivity of these methods. Student is able to understand, design, improve and apply newest noninvasive methods for early detection of cancer and melanoma.

theoretical teaching

1.Introduction to cancer research : influential factors, structural, energy and informational differences between normal and cancer cell. Genetics and biochemistry of cancer.
2. Cell cycles: chromosomes and chromosome duplication. Spindle apparatus. Regulatory mechanisms.Cell cycles in healthy and cancer cell.
3.Molecular basics of cancer: tumor markers, mechanism of action. Types and suitable choice of marker for diagnostic procedure. Sensitivity and specificity.
4. Existing methods, techniques, and tools for diagnostics: melanoma and skin cancer, cervical, colorectal, oral cavity and breast cancer. Brain tumor.
5. Diagnostics of melanoma and skin cancer: structure and function of the skin. Dermoscopy methods and techniques. UV/VIS/IR spectroscopy and opto-magnetic spectroscopy in the early diagnostics of skin cancer, skin lesions and melanoma.
6. Diagnostics of cervical cancer: structure and function of the epithelial cervical tissue. Methods and techniques for early diagnosis of cervical cancer using UV/VIS/IR and opto/magnetic spectroscopy (analysis of smeared samples (PAP)).
7. Diagnostics of colorectal cancer: structure and function of the epithelial colorectal tissue. Methods and techniques for early diagnosis of colorectal cancer using UV/VIS/IR and opto/magnetic spectroscopy (excision samples and smeared samples).
8. Diagnostics of oral cavity cancer: structure and function of the oral cavity epithelial tissue. Methods and techniques for early diagnosis of oral cavity cancer using UV/VIS/IR and opto/magnetic spectroscopy.
9. Diagnostics of breast cancer: structure and function of breast tissues. Spectroscopic and opto-magnetic methods for analysis of biopsy samples and in vivo . Methods and techniques for early diagnosis of breast cancer using UV/VIS/IR and opto/magnetic spectroscopy.
10. Diagnostics of brain tumor : structure and function of the brain. Existing methods for

diagnostics of the brain tumor. New methods for early detection.

practical teaching

1. Seminar paper: assigning paper theme in the field of early cancer diagnostic, instructions for acquiring scientific literature, instructions on methodology of scientific research
2. Laboratory work: UV/VIS/IR spectroscopy,fluorescence spectroscopy and opto-magnetic spectroscopy in early detection of skin cancer and melanoma; hardware-software solutions in dermoscopy for early detection of skin lesions, skin cancers and melanoma
3. Laboratory work: UV/VIS/IR spectroscopy and opto magnetic spectroscopy in early detection of cervical cancer (smear test). Comparison with PAP test.
4. Laboratory work: UV/VIS/IR spectroscopy and opto magnetic spectroscopy in early detection of colorectal cancer (excision samples, smear samples); hardware-software solutions for early detection of colorectal cancer
5. Laboratory work: UV/VIS/IR spectroscopy and opto magnetic spectroscopy in early detection of oral cavity cancer (oral cavity smear samples, in vivo diagnostics using oral camera); hardware-software solutions for early detection of oral cavity cancer
6. Laboratory work: UV/VIS/IR spectroscopy and opto magnetic spectroscopy in early detection of breast cancer (tissue biopsy, noninvasive in vivo diagnostics); hardware-software solutions for early detection of breast cancer
7. Laboratory work: UV/VIS/IR spectroscopy and opto magnetic spectroscopy in early detection of brain tumor (noninvasive in vivo diagnostics); hardware-software solutions for early detection of brain tumor

prerequisite

Defined in the curriculum of study module Biomedical Engineering

learning resources

1. Written course material (handout)
2. Scientific articles (KOBSON) - University network is available on laboratory computers (Nanolab) and cabinet 300
3. MATLAB, Excel
4. UV/VIS, VIS/IR Hamamatsu spectrometers, spektrofluorometer SKIN/SKAN, Opto-magnetic apparatus- instruments are available in the laboratory of Biomedical Engineering department – Nanolab

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 33

active teaching (practical)

auditory exercises: 0
laboratory exercises: 12
calculation tasks: 0
seminar works: 1
project design: 0
consultations: 6
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 3
check and assessment of seminar works: 9
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 6
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 30
laboratory exercises: 10
calculation tasks: 0
seminar works: 15
project design: 0
final exam: 35
requirements to take the exam (number of points): 35

references

M. A. Hayat (ed.), Methods of Cancer Diagnosis, Therapy and Prognosis, Volume 1-6, Springer, 2009-2011
R. Dummer, M. R. Pittelkow, K. Iwatsuki, A. Green, N. M. Elwan, Skin Cancer - A World-Wide Perspective, Springer, 2011
Lindon, J., Tranter, G., Holmes, J., Encyclopedia of Spectroscopy and Spectrometry, Elsevier, 2000.
Koruga, Dj., Tomić, A., System and Method for Analysis of Light-matter Interaction Based on Spectral Convolution, US Patent Pub. No.: 2009/0245603, Pub. Date: Oct. 1, 2009
Bronzino J. (ed.) The Biomedical Engineering Handbook, CRC Press, 1995

Fractal mechanics

ID: MSc-0272
teaching professor: Коруга Љ. Ђуро
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: control engineering

goals

The goal of this subject is to teach a student to apply multi-fractal system theory in a field of biomedical engineering; to learn to use mathematical apparatus of fractal theory and modeling of embryological process, formation and functioning of tissues, organs, organ subsystems and entire organism; to master knowledge about classical, quantum approach to analyse tissues; to maser fractal image processing and fractal chart pattern analysis; to learn to define diagnostic parameters, algorithms and instruments for determining functional conditions of organs and organism (normal conditions and pathological conditions)on the basis of fractal analysis of para/diamagnetic data.

learning outcomes

Student gains the ability for fractal processing of images and charts, and defining the parameters of tissues and biological systems that determine the functional state of organs and organism, as a basis for design of parameters which are meant to be measured by biomedical instrumentation in order to help in diagnostics.

theoretical teaching

Mathematical fundamentals of theory of fractals and multifractals. Fractals and fractal dimensions. Dynamic systems, Lyapunov exponents, Kolmogorov entropy and information. Fractal image processing and fractal chart pattern analysis. Random perturbations of Cantor triad set and DNA. Embryogenesis as fractal codogenic dynamics space-time-mass. Modeling processes in general and special embryology. Studying conformational states and changes of a system. Parameters of multifractal matrix which determines functional states of biomolecules, tissues, organs and organism : collagen, microtubules, hemoglobin, clathrin, cardiovascular system, nervous system etc. Comparative analysis of fractal algorithm and classical models and medical practice : skin cancer, melanoma, Alzheimer's disease etc.

practical teaching

Computer simulation of a fractal embryogenesis model. Computer simulation of diagnostic fractal algorithm. Formation of parameters which determine diagnostic multifractal matrix of biomolecules, tissues, organs and organism. Measuring para/dimagnetic properties of tissue, tissue oxigenation, fractal analysis of dermoscopic images, fractal analysis of EEG signal, fractal analysis of spectroscopic skin condition diagram, fractal analysis of a human body based on the body properties, mechanical, thermal, electric, magnetic and other properties.

prerequisite

Defined by the study curriculum of Biomedical engineering module

learning resources

1. Written course material (handouts);

2. Koruga Dj., Fractal mechanics, Science-DonVas, Belgrade, 2012
3. Muncan J., Fractal mechanics - practicum, Belgrade, 2012
4. Web sources on fractals, embryology, cardiovascular system, nervous systems etc.
5. Laboratory Nanolab1 utilities : the device for making thin films, NanoProb microscope with an integrated STM/AFM/MFM, electrochemical cell and nano fluid cell; UV/VIS/NIR spectrometers and their corresponding evaluation softwares

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 40

active teaching (practical)

auditory exercises: 10
laboratory exercises: 2
calculation tasks: 4
seminar works: 3
project design: 0
consultations: 1
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 5
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 5
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 50
laboratory exercises: 0
calculation tasks: 0
seminar works: 10
project design: 0
final exam: 30
requirements to take the exam (number of points): 40

references

Falconer,K., Fractal geometry, John Wiley , Chichester, 1990.
Wolpert,L.,Principles of Development, Oxford Univrsity Press, 2002
Larsen, W.J. Human Embriology, Churchill livingstone, New York, 1997
Valentinuzzi,M.E., Understanding the Human Machine: A Primer for Bioengineering, World Scietific, New Jersy, 2004
Lebscher,D-E, The Geometry of time,Wiley-VCH Verlag GmbH, Weinheim,2005

Fuzzy Control Systems

ID: MSc-0138
teaching professor: Рибар Б. Зоран
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: control engineering

goals

•Understanding of fuzzy approach to modeling phenomenon, process and systems
•Introduction to basic of fuzzy set theory and fuzzy control theory
•Analysis, design and simulation of fuzzy control systems using Matlab/Simulink software

learning outcomes

Knowledge and understanding of:
•Fuzzy set, fuzzy logic and fuzzy control theory
•Design of fuzzy controllers and fuzzy systems
•Synthesis of various fuzzy control algorithms
•Siimulation and practical realization of fuzzy control systems using PC and programing software C and Matlab/Simulink.

theoretical teaching

Fuzzy set theory. Fuzzy relations, operations on fuzzy sets. Fuzzy logic: linguistic variables, fuzzy rules, approximate reasoning. Fuzzy systems: fuzzy rule base, fuzzy inference engine, fuzzifier, defuzzifier, mathematical representations of fuzzy systems. Fuzzy control: theoretical and practical approach. Design and analysis of fuzzy controllers, fuzzy PID controllers. Mamdani and Takagi-Sugeno fuzzy systems. Fuzzy systems as universal approximators. Stability of fuzzy systems: direct and indirect Lyapunov's method. Nonconventional fuzzy control algorithms. Fuzzy tuning of classical conventional controllers. Fuzzy tracking control. Fuzzy sliding mode control. Fuzzy supervisory control, Fuzzy gain scheduling. Adaptive fuzzy control: direct and indirect, self-organizing fuzzy control. Application of fuzzy control.

practical teaching

PA:
Fuzzy sets, fuzzy relations, operations on fuzzy sets. Fuzzy logic: linguistic variables, fuzzy rules, approximate reasoning. Fuzzy systems: fuzzy rule base, fuzzy inference engine, defuzzification methods, mathematical representations of fuzzy systems. Fuzzy control: Mamdani i Larsen methods. Design and analysis of conventional fuzzy controllers: P, PD, PI, PID controllers. Mamdani and Takagi-Sugeno fuzzy systems. Analysis and synthesis of various fuzzy control algorithms based on sliding mode control, tracking control and adaptive control.

PL:
Matlab, Simulink, Fuzzy toolbox. Synthesis and simulation conventional and nonconventional fuzzy control algorithms using Matlab. Practice and experiments: realization of fuzzy control systems of electrohydraulic and electropneumatic servosystem using PC and PLC.

prerequisite

Defined by curriculum of the study programme.

learning resources

•Fuzzy control systems hands-out on: http://au.mas.bg.ac.yu/Nastava-Kau/Nastava_Download.html
•Electrohydraulic control system, Automatic Control Laboratory, Faculty of Mechanical engineering
•Electropneumatic control system, Automatic Control Laboratory, Faculty of Mechanical engineering, Belgrade
•PC and PLC computers, Automatic Control Laboratory, Faculty of Mechanical engineering, Belgrade

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 18
laboratory exercises: 12
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 4
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 6
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 40
laboratory exercises: 20
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

D. Driankov, H. Hellendoorn and M. Reinfrank, "An Introduction to Fuzzy Control" , Springer Verlag, 1996.
K. M. Passino, S. Yurkovich, "Fuzzy Control", Addison-Wesley, 1998.

Fuzzy Control Systems

ID: MSc-0642
teaching professor: Јовановић Ж. Радиша
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: control engineering

goals

•Understanding of fuzzy approach to modeling phenomenon, process and systems
•Introduction to basic of fuzzy set theory and fuzzy control theory
•Analysis, design and simulation of fuzzy control systems using Matlab/Simulink software

learning outcomes

Knowledge and understanding of:
•Fuzzy set, fuzzy logic and fuzzy control theory
•Design of fuzzy controllers and fuzzy systems
•Synthesis of various fuzzy control algorithms
•Siimulation and practical realization of fuzzy control systems using PC and programing software C and Matlab/Simulink.

theoretical teaching

Fuzzy set theory. Fuzzy relations, operations on fuzzy sets. Fuzzy logic: linguistic variables, fuzzy rules, approximate reasoning. Fuzzy systems: fuzzy rule base, fuzzy inference engine, fuzzifier, defuzzifier, mathematical representations of fuzzy systems. Fuzzy control: theoretical and practical approach. Design and analysis of fuzzy controllers, fuzzy PID controllers. Mamdani and Takagi-Sugeno fuzzy systems. Fuzzy systems as universal approximators. Stability of fuzzy systems: direct and indirect Lyapunov's method. Fuzzy tuning of classical conventional controllers. Nonconventional fuzzy control algorithms. Fuzzy tracking control. Fuzzy sliding mode control. Fuzzy supervisory control. Adaptive fuzzy control: direct and indirect, self-organizing fuzzy control. Application of fuzzy control.

practical teaching

PA:
Fuzzy sets, fuzzy relations, operations on fuzzy sets. Fuzzy logic: linguistic variables, fuzzy rules, approximate reasoning. Fuzzy systems: fuzzy rule base, fuzzy inference engine, defuzzification methods, mathematical representations of fuzzy systems. Fuzzy control: Mamdani i Larsen methods. Design and analysis of conventional fuzzy controllers: P, PD, PI, PID controllers. Mamdani and Takagi-Sugeno fuzzy systems. Analysis and synthesis of various fuzzy control algorithms based on sliding mode control, tracking control and adaptive control.

PL:
Matlab, Simulink, Fuzzy toolbox. Synthesis and simulation conventional and nonconventional fuzzy control algorithms using Matlab. Practice and experiments: realization of fuzzy control systems of electrohydraulic and electropneumatic servosystem using PC and PLC.

prerequisite

Defined by curriculum of the study programme.

learning resources

•Fuzzy control systems hands-out on: http://au.mas.bg.ac.yu/Nastava-Kau/Nastava_Download.html
•Electrohydraulic control system, Automatic Control Laboratory, Faculty of Mechanical engineering
•Electropneumatic control system, Automatic Control Laboratory, Faculty of Mechanical engineering, Belgrade
•PC and PLC computers, Automatic Control Laboratory, Faculty of Mechanical engineering, Belgrade

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 5
laboratory exercises: 15
calculation tasks: 0
seminar works: 0
project design: 10
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 6
colloquium, with assessment: 4
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 30
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 30
final exam: 30
requirements to take the exam (number of points): 30

references

D. Driankov, H. Hellendoorn and M. Reinfrank, "An Introduction to Fuzzy Control" , Springer Verlag, 1996.
K. M. Passino, S. Yurkovich, "Fuzzy Control", Addison-Wesley, 1998

Industral Automation

ID: MSc-0599
teaching professor: Ристановић Р. Милан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: control engineering

goals

To introduce students to the contemporary industrial control systems, design and technology of their realization, component selection and practical implementation of simple solutions.

learning outcomes

The acquired knowledge is used in engineering practice. The student is competent to understand modern control systems in the industry, component selection and practical implementation of simple solutions.

theoretical teaching

Overview of the development of automation in the industry. Electrical control. Components of electrical contact control (push buttons, proximity switches, contactors and relays, time relays, switches, relays, pulse relays, residual current device, safety shutdown, bouncing contacts, high voltage electrical discharge). Displaying electrical contact control. Basic coupling with electric contact control. Control of three-phase induction motors. Pneumatic control. Perform pneumatic installation. Compaction systems and air preparation. Pneumatic cylinders. Pneumatic valves. Electro-pneumatic control. Programmable controllers. Characteristics of programmable controllers. CPU structure. Users program. Input/output modules. Programming the controller according IEC61131-3. Programming languages. Writing programs. Basic functions. Timers. Counters. Sekvential control. Communication between the controllers (Profibus, Profinet, ...). Human-machine interface. Distributed control and SCADA systems.

practical teaching

Examples of implemented systems. Practical aspects of election management system components. Realization of simple solution. PLC controller. Development of SCADA system.

prerequisite

Basic knowledge in automatic control, computer control and digital systems.

learning resources

Laboratory

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 25

active teaching (practical)

auditory exercises: 10
laboratory exercises: 15
calculation tasks: 5
seminar works: 0
project design: 5
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 5
colloquium, with assessment: 5
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 50
laboratory exercises: 5
calculation tasks: 0
seminar works: 0
project design: 10
final exam: 30
requirements to take the exam (number of points): 50

references

M. Ristanovic, Industrial Automation, printed lectures
Schmiedt, Dietmar et. al, "Steuern und Regeln für Maschnienbau und Mecha- tronik", Verlag Europa-Lehrmittel, Haan-Gruiten, 2010.
Berger, Hans "Automating with STEP 7 in LAD and FBD", Publicis Corporate Publishing, Erlangen, 2005.
Tapken, Herbert "SPS Theorie und Praxis", Verlag Europa-Lehrmittel, Haan-Gruiten, 2011.
Stenerson J., Industrial automation and process control, Prentice Hall, 2003

Informational Technologies in Medicine

ID: MSc-0682
teaching professor: Коруга Љ. Ђуро
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 2
final exam: written
parent department: control engineering

goals

Introducing students with fundamental principles of applied informational technologies in medicine, with a goal of examining the important characteristics of implementations of new technologies in medicine. Simulation of realistic problems and specific requirements for implementation of logical structures in hospitals, telediagnostics, and analysis of biological systems on molecular level.

learning outcomes

By attending this course student becomes capable of analyzing the problems of organizing informational structures in medical institutions, practical application, and development of algorithms and structures applicable in telemedicine, and knowledge necessary for detailed analysis of biological structures on molecular level with application of scientific methods, procedures, computational techniques and equipment.

theoretical teaching

Informational systems, relation user-informational system, informational system in medicine, structure of informational systems in medicine.
Informational systems in hospitals, types, infrastructure, development.
Clinical informational system, definition, structure, problems in development of system modules and their coexistent functioning.
Informational systems in laboratories, defining, structure, requirements, modularity.
Subsystems of informational systems in medicine, support in main systems.
Manager informational systems, definitions, structures, requirements in medical institutions.
Regional informational systems, structure, standardization of data's and communication between medical institutions.
Perspective of development of informational systems in medicine, trends, electronic health book.
Telemedicine, software, hardware, trends.
Bioinformatics, definition, historical development. software tools, data basis available for free on internet, analysis of sequences, 3D protein structures.

practical teaching

prerequisite

Necessary: Fundamentals of Biomedical Engineering.

learning resources

Written material from lectures (handouts).

number of hours

total number of hours: 30

active teaching (theoretical)

lectures: 10

active teaching (practical)

auditory exercises: 2
laboratory exercises: 8
calculation tasks: 2
seminar works: 2
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 2
check and assessment of projects: 0
colloquium, with assessment: 1
test, with assessment: 1
final exam: 2

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 30
laboratory exercises: 0
calculation tasks: 10
seminar works: 20
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

Bemmel, J., et al.: Handbook of Medical Informatics, Springer -Verlag, 1997.
Velde, R., Degoulet, P.: Clinical Information systems, Springer, 2003.
Norris, A.C.: Essentials of Telemedicine and Telecare, Wiley, 2002.
Claviere, J.M., Notredame, C.: Bioinformatics for Dummies, Wiley, 2003.

Intelligent Buildings

ID: MSc-0656
teaching professor: Ристановић Р. Милан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: control engineering

goals

To introduce students to the concept of intelligent buildings, technical systems in modern buildings and control systems technology and their integration.

learning outcomes

The acquired knowledge is used in engineering practice. The student is competent to understand the technical sub-systems in modern buildings, their configuration and mutual integration of electrical and mechanical systems and management concepts.

theoretical teaching

The definition of intelligent buildings. Technological systems in intelligent buildings. Introduction to digital control systems: analog / digital input / output values, sensors, actuators, digital controllers. Basic communication standards and their characteristics. Control algorithms and tuning.
Management of central heating systems. Control of boilers. Control of substations. Outdoor temperature compensation. Central and zone control. Control in the solar system. Managing in the air conditioning. Typical control schemes of air conditioning. Cascade control. Secvential control. Regulation of air humidification. Control of air handling unit with variable flow. Lighting control systems. Lighting control system components, analog / digital control and lighting control strategies. Protection systems and solar radiation and control strategies. Measuring energy consumption. Fire protection systems. Access control systems. Building management systems. Application of Internet technology in control.

practical teaching

Understanding the physical implementation of sensors, digital controllers and drivers. Understanding the physical implementation of control systems in buildings. Programming and networking of digital controllers.
Realization of simple solutions.

prerequisite

Бasic automatic control knowledge and digital systems.

learning resources

Laboratory

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 5
laboratory exercises: 20
calculation tasks: 0
seminar works: 0
project design: 5
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 5
colloquium, with assessment: 5
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 50
laboratory exercises: 5
calculation tasks: 0
seminar works: 0
project design: 10
final exam: 30
requirements to take the exam (number of points): 50

references

M. Ristanovic, Intellingeng Buildings, printed lectures
Shengwei Wang, Intelligent Buildings and Building Automation, Spon Press, New York, 2010
H. Merz, T. Hansemann, C. Huebner, Building Automation, Springer-Verlag, Berlin Heidelberg, 2009
C.F. Mueller, Regelungs- und Steuerungstechnik in der Versorgungstechnik, 2002

Intelligent Control Systems

ID: MSc-0657
teaching professor: Јовановић Ж. Радиша
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: control engineering

goals

•Introduction to methods for the analysis and design of intelligent control systems.
•Gaining practical knowledge of several of the main techniques of intelligent control and an introduction to some promising research directions.
•Use of the computer for simulation and evaluation intelligent control systems.

learning outcomes

The course involve:
•understanding of the functional operation of a variety of intelligent control techniques
•the study of control-theoretic foundations,
•learning analytical approaches to study properties (especially stability analysis),
•acquiring of the knowledge of intelligent systems design (control, production, etc.) based on combinations of various theories: simulation, neural networks, fuzzy systems, genetic algorithms, evolutionary algorithms, etc.
•use of the computer for simulation and evaluation intelligent control systems through Matlab software.

theoretical teaching

Introduction of Intelligent Control. Conventional and intelligent control.
Knowledge representation and processing. Soft computing. Fuzzy sets, fuzzy Logic control. Control system tuning. Intelligent hierarchical control. Fundamentals of neural networks. Neural networks and applications. Evolutionary computing. Genetic algorithms and optimal search.

practical teaching

PA:
Practical work includes computational exercises that follow the content of course.

PL:
Application programming languages Matlab in the simulation and design intelligent control systems.
Practice and experiments: control of various plants using various intelligent control techniques.

prerequisite

Defined by curriculum of the study programme.

learning resources

•Intelligent control systems hands-out on: http://au.mas.bg.ac.yu/Nastava-Kau/Nastava_Download.html
•Computer control system, Automatic Control Laboratory, Faculty of Mechanical Engineering,

Belgrade.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 18
laboratory exercises: 12
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 5
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 5
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 40
laboratory exercises: 20
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

Karray, F. O. and de Silva, C. W., Soft Computing and Intelligent Systems Design—Theory, Tools, and Applications, Addison Wesley, 2004.d

Introduction to nanosystems

ID: MSc-0681
teaching professor: Матија Р. Лидија
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 2
final exam: written
parent department: control engineering

goals

Introduction to basic elements of nanosystems: materials, energy, information, organization and control. Basic types and characteristics of nanomaterials and nanoparticles; fundamental methods, techniques and equipment for characterization. Intermolecular forces, potential Codogen nanomaterials and biomimicry in nanosystems. Self-assembly and organization. Principles of nanorobotics design.

learning outcomes

Acquiering of fundamental knowledge in nanosystems that could enable problem analysis and possibility of predicting solutions for nanosystem problems by application of scientific methods and procedures. Introduction to basic principles of work for STM and AFM. Integration of physics of materials knowledge, energetics and informatics in the aim of recognition of basic criteria for differentiation of nanosystems from clasical technical systems.

theoretical teaching

Basic elements of nanosystems: material, energy, information, organization amd control. Importance of considering of processes on nano level. Intermolecular interactions, thermodynamical and statistical aspects of nanomaterials. Introduction to techniques for characterization of nanomaterials with spectroscopic analysis of electromagnetic waves. Mode of operation of radiation and scanning mycroscope. STM and AFM. Basic and additional modes of operation and moduls. Self-assembly criteria and examples of molecular systems formed in the process of self-assembly. Inorganic and organic systems, unspecific and non covalent interactions. Molecular recognition, biomimicry. Theoretical (physical and chemical) aspects of bilogical and techical nanosystems. Nanosystem synthesis, molecular construction blocks. Control of nanosystem synthesis and nanorobots.

practical teaching

Introduction to processes on nano level. Comparison of physical and biological systems on nano level. Basic equations and calculations of characteristic interaction intensity. Comparison with micro and macro systems. Fundamental calculations of characteristic properties. Methods for nanosystem simulation. Methods of computer simulations and optimization of nanosystems. Introduction to nanotechnology instrumentation for vizualization of nanosystems. Basics of software and hardware. Basics of control. Introduction to software simulation of molecular nano systems. Calculated models of nonspecific and noncovalent interactions. Practical aspects and examples of application of biological and technical nano systems. Introduction to instrument assembly for nano system synthesis and introduction to nanorobotic assembly.

prerequisite

Prerequisition for attending this course is that student is regulary attending MAS first semester.

learning resources

1) Handouts from lectures, 2) Matija L., Kojic D., Vasic A., Jovanovic T., Bojovic B., and Koruga Dj., Introduction to nanotechnologies, DonVas/NAUKA, Belgrade, Serbia, 2011, 3) Nanolaboratory with JEOL-STM/AFM instrumentation for nanotechnologies and JEOL instrumentation for nanofilms.

number of hours

total number of hours: 30

active teaching (theoretical)

lectures: 13

active teaching (practical)

auditory exercises: 0
laboratory exercises: 3
calculation tasks: 2
seminar works: 1
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 1
check and assessment of lab reports: 0
check and assessment of seminar works: 1
check and assessment of projects: 0
colloquium, with assessment: 1
test, with assessment: 3
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 0
laboratory exercises: 30
calculation tasks: 10
seminar works: 10
project design: 20
final exam: 30
requirements to take the exam (number of points): 40

references

Mansoori Ali G.: Principles of Nanotechnology, University of Illinois, 2005.
Wiesendanger R.: Scanning Probe Microscopy and Spectroscopy, University of Hamburg, 1994
Bard.A.J., Integrated Chemical Systems: A Chemical Approach to Nanotechnology, John Wiley, New York, 1994
Rogers,B., Nanotechnology: Understanding Small Systems, CRC Press, Boca Ratom, 2008

Linear stochastic systems

ID: MSc-0314
teaching professor: Дебељковић Љ. Драгутин
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: control engineering

goals

To be familiar with the knowledge of stochastic, ergodic random processes and with the methods for control system analysis and design in time and frequency domain.
Based on essential stochastic signal characteristics to be able to estimate fundamental system behavior, when random processes are present on the inputs of the system.
To able to implement some of optimization techniques in such cases.

learning outcomes

To be familiar, to introduce as well basic principle of contemporary probability theory and mathematical statistics and all of that to implement to linear continuous time invariant automatic control systems, when they are subjected to the influence of random signals.
To be capable to implement for direct implementation of different control strategies.

theoretical teaching

Some basic knowledge from probabilistic theory. Random variables.Stochastic processes. Linear system analysis in time domain. Linear system analysis in frequency domain. Linear system analysis in state space. Linear system design based on mean square error. Linear system design in time domain. Linear system design in frequency domain. Linear system design in complex domain. Parameter system estimation - Kalman - Bucy filter. Kalman - Viener filter.

practical teaching

Filtering, interpolation, prediction. Stochastic processes. Linear system analysis in time domain. Linear system analysis in frequency domain. Linear system analysis in state space. Linear system design based on mean square error. Linear system design in frequency domain. Linear system design in complex domain. Viener - Hoppf equation. Bode- Shanons method. Viener - Kolmogorov approach. Parameter system estimation - Kalman - Bucy filter.

prerequisite

Given exams from subjects : Automatic Control and Control System Design.

learning resources

D.Lj.Debeljković, "Linear Stochastic Control Systems", Science book, Belgrade, 1985, Second ed. Faculty of Mechanical Engineering, Belgrade 1992, pages 257.

D. Lj. Debeljkovic, Analysis, Synthesis and Estimation of Linear Control Systems in the Presence of Random Signals, Faculty of Mechanical Engineering, Belgrade, 2010 (in Serbian), pp. 444, ISBN 978 – 86 – 7083 – 683 – 9.

Handouts

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 30
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 2
check and assessment of projects: 4
colloquium, with assessment: 4
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 30
laboratory exercises: 0
calculation tasks: 0
seminar works: 20
project design: 10
final exam: 30
requirements to take the exam (number of points): 30

references

D.Lj.Debeljković, “Linear Stochastic Control Systems”, Science book, Belgrade, 1985, Second ed. Faculty of Mechanical Engineering, Belgrade 1992, pages 257.
D. Lj. Debeljkovic, Analysis, Synthesis and Estimation of Linear Control Systems in the Presence of Random Signals, Faculty of Mech.Eng., Belgrade, 2010 pp. 444, ISBN 978 – 86 – 7083 – 683 – 9.
Хандоутс

Linear System Design

ID: MSc-0307
teaching professor: Дебељковић Љ. Драгутин
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: control engineering

goals

Student to be familiar with basic demands in control system design (synthesis) introducing the basic facts about essential system characteristics working in steady state or in transient process.
To be informed with wide spectrum of different control design methods and approaches within the contemporary real control, mostly feedback automatic control systems.

learning outcomes

To be familiar, to accept and be capable to use some of offered methods in control system design and to be learned to implement them on every particular problem from the class of systems that have been treated within the course.
It is expected that one should be capable to apply some of particular control design methods in real systems operating time and to implement them on real objects and processes mostly for particular class of linear feedback control systems.

theoretical teaching

System analysis and synthesis.
Criteria for evaluation of systems performance.
Demands under synthesis problem.
Hale-s chart and Nichols diagram.
Parametric plane methods.
Structural synthesis and design.
Regulator matching.
Compensator design. Bode diagram . Root locus method.
Performance index.
Optimizations methods - elementary approach in parameter plane.
Synthesis of particular class of feedback control systems.

practical teaching

Steady state systems characteristics. Dynamic response and its characteristics. Some criteria in time domain. Some criteria in frequency domain. Hale-s chart and Nicholas diagram. Complex plane. Parameter plane control system design methods. Structural design. Bodes diagrams. Root locus design. Controller matching. Series compensator design. Integral criteria in control system design. System optimization - elementary approach based on parameter plane methods. Control design of particular classes of control systems.

prerequisite

There is one restriction.
The exam from subject (course) Automatic Control should be given.

learning resources

D.Lj.Debeljković, B.R.Milojković, “Linear System Design”, Faculty of Mechanical Engineering, Belgrade, 1981 ,Second ed .1987, pages 383.

D.Lj.Debeljković, “Linear System Design - Problems and Exercises”, Faculty of Mechanical Engineering, Belgrade, 1981, Second ed. 1988, pages 253.

D. Lj. Debeljkovic, “Control System Design: Conventional and Modern Approach ", Čigoja press, Belgrade, (in Serbian), 2008, pages 399.

D. Lj. Debeljkovic, “Control System Design: Pole Placement Methods, Part I, Part II, Part III, Mechanical Engineering, Belgrade, 2005, 2007, 2008.

(handouts)

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 20
laboratory exercises: 0
calculation tasks: 0
seminar works: 6
project design: 4
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 2
check and assessment of projects: 4
colloquium, with assessment: 4
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 30
laboratory exercises: 0
calculation tasks: 0
seminar works: 20
project design: 10
final exam: 30
requirements to take the exam (number of points): 30

references

D.Lj.Debeljković, B.R.Milojković, “Linear System Design”, Faculty of Mechanical Engineering, Belgrade, 1981 ,Second ed .1987, pages 383.
D. Lj. Debeljkovic, “Control System Design: Conventional and Modern Approach ", Čigoja press, Belgrade, (in Serbian), 2008, pages 399.
Handouts

Nanomedical Engineering

ID: MSc-0728
teaching professor: Матија Р. Лидија
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: control engineering

goals

Student will get knowledge of наносциенце анд nanotechnology applications in medicine together with good practical laboratory work in characterization of biomaterials with nanotechnological methods, techniques and instrumentation. Student will get knowledge of modern diagnostics and therapeutic nanotechnological methods in medicine and will learn how to prepare classical and biological samples and to characterize them with nanotechnological instrumentation.

learning outcomes

The abbility of students to interpret the advantages of applications of new nanotechnology devices in medicine against the classical ones. Understanding principles of functioning and specificities of the conditions in which the devices are applied. The abbility of modifing technical solutions in nanotechnologies and quantum information technology in order to make applications more effective.

theoretical teaching

Short history of medicine:From origins of menkind to Asclepius.From Asclepius to Hippocrates.From Hippocrates to healers.From healers to van Leeuwenhoek.From van Leeuwenhoek to DNA discovery.From DNA to quantum medicine.From quantum medicine to nanomedicine;Basics of molecular medicine:Classical medical approach to diseases. Resorption, distribution, metabolism and excretion of drugs.Interactions and undesirable effects of drugs.Molecular basics of diseases.Basics of molecular nanotechnology and its applications in medicine;Basics of nanomedicine:Nanoparticles and nanomaterials in medicine.Quantum dots based on semiconducting nanoparticles.Quantum dots based on nanomaterials (fullerenes).Adding of hydroxyl groups and other molecules to basic nanomaterials.Use of AFM for intermolecular bonding forces measurements in saline;Nanotechnology and nanobiomedicine:Comparison of classical and nanotechnological methods and techniques use in diagnostics and treatment.Advantages and risks of nanoparticles use in medicine;Nanosensors:Nanosensors for electrical,electro-chemical and optical measurements.Nanosensors for food and beverage analysis;Microtubules:Actine filaments.Intermedial fibers.Microtubules.Proteins added to microtubules.Molecular motors.Myosin.Kinesin.Dynein.Cell division.Cytokinesis;Nanotechnology in pharmacy:Possibilities and range of nanopharmacy.Production of nanoparticles.Barriers in organism.Pharmaceutical nanosystems engineering.Intelligent systems for drug releasing;Nanotechnology in implantology:Nanotechnological implants in rehabilitation medicine.Nanoimplants in stomatology.Characterization of stomatological materials by AFM.Nanoimplants in dermatology;Nanotechnology and diabetes:Main sorts of diabetes.Insulin.Complications.Medical nanobots for diabetes control.Methods;Biocompatibility of nanomedical materials:Biocompatibility of coated diamond material.Biocompatibility of fullerenes and carbon nanotubes.Biocompatibility of fluoro-carbon polymers.

practical teaching

Drugs spectroscopy:UV-Vis,IR spectroscopy;Nanotechnological characterization of drugs:STM, AFM and MFM application.Paramagnetism degree assessment of drugs.Paramagnetism/diamagnetism dynamics of drugs at nanotesla level;Biocompatibility of nanomaterials:Analysis and characterization of nanomaterials surface with nanotechnological instrumentation.Toxicological tests of nanomaterials and nanoparticles;Nanoprobe measurements:Dynamic nanophotonic probes.Spectral ballistic probes based on nanoparticles size.Quantum nanoprobes based on encapsulated fullerenes.Adding of soluble groups to encapsulated fullerenes;Implants characterization:Implants characterization by STM, AFM and MFM.Implants characterization in saline by AFM.Sample preparing techniques.Assessment of mechanical,electrical and magnetic characteristics of materials.

prerequisite

Fractal Mechanics, Biomaterials in medicine and stomatology , Signal processing, Nanotechnology

learning resources

Written material for every lecture (Handouts), NanoLab: modern NanoProbe device with STM/AFM/MFM, Opto-magnetic spectroscopy device, Chemical Vapor Deposition for thin (nano) films, UV/VIS spectometer, NIR spectometer,microscopy

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 40

active teaching (practical)

auditory exercises: 2
laboratory exercises: 7
calculation tasks: 0
seminar works: 2
project design: 2
consultations: 1
discussion and workshop: 6
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 2
check and assessment of seminar works: 2
check and assessment of projects: 2
colloquium, with assessment: 1
test, with assessment: 3
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 15
laboratory exercises: 20

calculation tasks: 0
seminar works: 10
project design: 10
final exam: 35
requirements to take the exam (number of points): 40

references

Papić-Obradović, M., Miljković, S., Matija, L., Munćan, J., Koruga, Đ., Osnove Nanomedicine, Don/Vas Nauka, Beograd, 2011.
Matija, L., Kojić, D., Vasić, A., Bojović, B., Jovanović, T., Koruga, Đ., Uvod u nanotehnologije, Don/Vas Nauka, Beograd, 2011.
Kumar,S.S.R, at.al. Nanofabrication Towards Biomedical Applications, Wiley-VCHWeinhaimen, 2005.
Malsch,H.N., Biomedical Nanotechnology, CRS Press, Boca Raton, 2005
Freitas,R.A., Nanomedicine, Volume IIA:Biocompatibility, Lands Biscience, Austin, 2003.

Nanotechnology

ID: MSc-0727
teaching professor: Матија Р. Лидија
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: control engineering

goals

Goal of this subject is for students to acquire knowledges of: electron tunnelling phenomena, molecular atractve and repulsive forces, nanomaterials, conversion and transport of energy on nanoscale level. Introduction of basic methodes, techniques and devices for characterisation of nanomaterials: Scanning NanoProbe microscopy and spectroscopy. Nano electrochemical cell. Characterisation of conductive, magnetic and non-conductive materials: inorganice as well as biological. Nano films: characterisation and modification of sample surfaces by STM/AFM methodes.

learning outcomes

Student will obtain basic knowledges of nanotechnologies which will allow him to make analysis of certain problems and ability to predict solutions with scientific methods, processes and computer techniques. Student will be introduced with basic principles of opreration of STM and AFM microscope and be able to integrate knowledge of material physics, energy and information on nanoscale level for engineering nano-molecular sensores and machines.

theoretical teaching

Conditions for beginning and development of nanotechnology. Basic terms from experimental and theoretical aspects of scanning tunnelling mycroscopy and spectroscopy. Schroedinger equation and electron tunnelling. Technologioes based on electron tunneling effect. Organization of processes of electrochemical interactions. Characterization of materials based on intermolecular forces. Alternative methodes and techniques for spectroscopy and scanning tunnelling microscopy methodes. Introduction to applied nanotechnologies. General areas of application of scanning tunnelling microscope and nanoprobe microscopy. Studying of solid and liquid materials on nanoscale. Solid state physics on the level of nanometers. Application of nanotechnologies in research of organic molecules, drugs and biomacro molecules(nucleic acids, proteins and membrane aggregates). Metrology and standards in nanotechnology. Material modifications on nano level. Integrational aspects of nanotechnology based on physics and chemistry. System aproach to nano-molecular sensores and devices engineering.

practical teaching

Practical lessons: Demonstratory practice from nanotechnology instrumentation. Introduction to abilities and operations of scanning tunnelling microscope. Basic assemblies and principle of tunneling electron conrole. Practical work in sofrware for gathering data from sample analysis. Introduction with atomic force microscope. Comparing posibillities and results of STM and AFM. Basic assemblies and principle of attractional and repulsive forces controle. Nano consoles: characteristics, types, observing them by high magnification CCD camera. Nanomaterial images analysis. Introduction and operation with software tools for acquiring STM and AFM images. Difference between graphical and analytical data. Operation of nano-fluid cell and electrochemical cell.

prerequisite

Enlisted in 2nd semester of Master studies. Recomended: Introduction to nanosystems

learning resources

NanoLaboratory with Chemical vapor deposition device for making thin films, NanoProbe microscope with integrated STM/AFM/MFM, electrochemical cell and fluid cell.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 14
laboratory exercises: 8
calculation tasks: 3
seminar works: 3
project design: 0
consultations: 2
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 1
check and assessment of lab reports: 2
check and assessment of seminar works: 3
check and assessment of projects: 0
colloquium, with assessment: 1
test, with assessment: 3
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 25
laboratory exercises: 10
calculation tasks: 0
seminar works: 10
project design: 10
final exam: 35
requirements to take the exam (number of points): 35

references

Dj.Koruga, S.Hameroff, J.Withers, R. Loutfy, M.Sundareshan., Fullerene C60: History, physics,nanobiology, nanotechnology, North-Holland -Elsevier, Amsterdam, 1993
Hornyak,G.L. et. al, Introduction to nanoscience and nanotechnology, CRC Press, Boca Raton, 2009
Hanson,G.W., Fundamentals of nanoelectronics, Prentice Hall, New Jersey, 2008
Satto, R. et.al., Physical Properties of Carbon nanotubes, Imperial Colledge Press, London,1998
Cui,Y., Nanofabrication: Principles, capabilities and limits, Springer, Berlin, 2008

Neural networks and fuzzy logic

ID: MSc-0649
teaching professor: Јовановић Ж. Радиша
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: control engineering

goals

•Introduce students to the fundamental principles of artificial neural networks and artificial intelligence.
•Mathematical modeling of artificial neural networks and its application to science and technology.
•Understanding of fuzzy approach to modeling phenomenon, process and systems
•Introduction to basic of fuzzy set theory and fuzzy logic
•Analysis, design and simulation of fuzzy systems using Matlab/Simulink software
•Collaboration with experts in medicine, contol systems.

learning outcomes

•Acquiring the ability to analyze issues related to artificial neural networks, the establishment of mathematical models of biological systems using scientific methods, procedures, computer technology and equipment.
•Connecting the basic knowledge of anatomy and physiology, automatic control in order to achieve better manufacturing techniques, humane interaction man - machine.
•Knowledge and understanding of fuzzy set, fuzzy logic and fuzzy control theory.
•Knowledge and understanding of design of fuzzy controllers and various fuzzy control algorithms.

theoretical teaching

Central nervous system, neurons and artificial neural networks. The laws of learning, principles, Hebbian learning law, the law Vidroua learning. Perceptron, without and with internal layers. Artificial neural network by traveling povretnim error, delta rule. Hopfield-like neural networks, Kohonen artificial neural networks. Self-organizing map, adaptive resonance theory. Genetic algortihms.
Fuzzy set theory. Fuzzy relations, operations on fuzzy sets. Fuzzy logic: linguistic variables, fuzzy rules, approximate reasoning. Fuzzy systems: fuzzy rule base, fuzzy inference engine, fuzzifier, defuzzifier, mathematical representations of fuzzy systems. Fuzzy control: theoretical and practical approach. Design and analysis of fuzzy controllers, fuzzy PID controllers. Mamdani and Takagi-Sugeno fuzzy systems. Fuzzy-neural controllers.

practical teaching

PA:
Application of perceptron without internal layers in practical examples. Back propagation neural in practical examples. Kohonen artificial neural networks. Self-organizing mapping. Genetic algorithms.
Fuzzy sets, fuzzy relations, operations on fuzzy sets. Fuzzy logic: linguistic variables, fuzzy rules, approximate reasoning. Fuzzy systems: fuzzy rule base, fuzzy inference engine, defuzzification methods, mathematical representations of fuzzy systems, Mamdani i Larsen methods. Design and analysis of conventional fuzzy controllers: P, PD, PI, PID controllers. Mamdani and Takagi-Sugeno fuzzy systems. Analysis and synthesis of various fuzzy control

algorithms.

PL:
Matlab, Simulink, Fuzzy toolbox, Neuaral network toolbox. Synthesis and simulation fuzzy control algorithms and neural networks using Matlab. Practice and experiments: realization of fuzzy control of electrohydraulic and electropneumatic servosystem using PC and PLC.

prerequisite

Required: Automatic control, Bioautomatics
Preferred: Basic Biomedical Engineering, System approach to human anatomy and physiology

learning resources

•Neural networks and fuzzy logic hands-out on: http://au.mas.bg.ac.yu/Nastava-Kau/Nastava_Download.html
•Electrohydraulic control system, Automatic Control Laboratory
•Computer control system, Automatic Control Laboratory, Faculty of Mechanical Engineering.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 10
laboratory exercises: 15
calculation tasks: 0
seminar works: 5
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 5
check and assessment of projects: 0
colloquium, with assessment: 5
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 40
laboratory exercises: 0
calculation tasks: 0
seminar works: 20
project design: 0

final exam: 30
requirements to take the exam (number of points): 30

references

D. Driankov, H. Hellendoorn and M. Reinfrank, "An Introduction to Fuzzy Control" , Springer Verlag, 1996.

neural networs and fuzzy logic

ID: MSc-0680
teaching professor: Рибар Н. Срђан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 4
final exam: written
parent department: control engineering

goals

• Introduce students to the fundamental principles of artificial neural networks
• Mathematical modeling of artificial neural networks and its application to science and technology.
• Consideration fuzzy approach to modeling phenomena, processes, and systems.
• Understand the basics of the theory of fuzzy sets and fuzzy logic.
• Using MATLAB / Simulink for analysis, synthesis and simulation of fuzzy systems.
• Co-operation with experts from the medical field and automation.

learning outcomes

• Acquisition of the ability to analyze issues related to the neural network, the formation of mathematical models of biological systems using scientific methods, procedures, techniques, and computer equipment.
• Connecting basic knowledge of anatomy and physiology, the automatic control system in order to achieve better process technology, more human interaction man - machine.
• Knowledge and understanding of fuzzy sets, fuzzy logic and fuzzy control theory.
• Knowledge and understanding of the synthesis of fuzzy controlers and different fuzzy control algorithms.

theoretical teaching

Central nervous system, artificial neurons and artificial neural networks. The laws of learning, principles, Hebbian learning law, the Widrow's learning law. Perceptron, with and without inner layers. Artificial neural network with feedback error propagation, delta rule. Hopfield neural networks, Kohonnen artificial neural networks. Self-organizing mapping.
The theory of fuzzy sets. Phase relations, operations on fuzzy sets. Fuzzy logic: linguistic variables, fuzzy rules, approximately reasoning. Fuzzy systems: fuzzy rule base, fuzzy inference, fuzzifiers, defuzzifiers, mathematical representation of fuzzy systems. Fuzzy control: a theoretical and practical approach. Synthesis and analysis of fuzzy controller, fuzzy PID controllers. Mamdani and Takagi-Sugeno fuzzy systems. Neuro-fuzzy controllers.

practical teaching

Application of perceptron without internal layers in practical examples. Network with feedback error propagation. Kohonen neural network. Self-organizing mapping.
Fuzzy sets, relations, operations on fuzzy groups. Fuzzy logic: linguistic variables, fuzzy rules. Fuzzy systems: phase rule base, fuzzy inference, defuzzification, the mathematical representation of fuzzy systems Mamdani and Larsen methods. Synthesis and analysis of classical fuzzy controller: P, PD, PI and PID. Mamdani and Takagi-Sugeno fuzzy systems. Analysis and synthesis of different fuzzy algorithms.
Fuzzy Toolbox and Neural Network Toolbox MATLAB programming language. Application of MATLAB in the synthesis and simulation of control algorithms and fuzzy neural networks.
Experiment: Application of fuzzy algorithms and neural networks in the control of electro-hydraulic servo systems, and electro-pneumatic systems - implementation using PC and PLC

computer.

prerequisite

learning resources

• Script on page http://au.mas.bg.ac.yu/Nastava-Kau/Nastava_Download.htm
• Electro servosystem, Department of Automatic Control, EOP / LEO
• Computer Control System, Automatic Control Laboratory, Faculty of Mechanical Engineering, EOP / LEO

number of hours

total number of hours: 45

active teaching (theoretical)

lectures: 18

active teaching (practical)

auditory exercises: 5
laboratory exercises: 8
calculation tasks: 0
seminar works: 4
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 3
check and assessment of projects: 0
colloquium, with assessment: 3
test, with assessment: 0
final exam: 4

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 40
laboratory exercises: 0
calculation tasks: 0
seminar works: 20
project design: 0
final exam: 30
requirements to take the exam (number of points): 40

references

D. Driankov, H. Hellendoorn and M. Reinfrank, "An Introduction to Fuzzy Control" , Springer Verlag, 1996.

Nonlinear Systems 1

ID: MSc-0188
teaching professor: Лазић В. Драган
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: control engineering

goals

Getting started with the appearance of nonlinearity in the plants and processes, explanation of origins and types of nonlinearities and their interpretation in the analytical and programming format.
Introduction to complex mathematical methodology required for successful analysis and synthesis of nonlinear systems, identifying special characteristics of nonlinear systems, conditions for the proper linearization and determination of linearization domains.
Learning basic tools for checking the stability of nonlinear systems.

learning outcomes

The analysis from the standpoint of the theory of nonlinear systems.
Interpretation of nonlinear programming through the possibility of forming a credible programming model of nonlinear systems
Analysis of complex nonlinear systems described by mathematical models, knowledge of effects that can occur due to the existence of the nonlinearity in the system
Competence to conduct the analysis of the nonlinear systems in the time domain and the state space

theoretical teaching

Definition of nonlinearity, its physical origin. Various types of nonlinearities and their descriptions. Types of nonlinear systems. Conditions of instability and stability of the system. State space, an integral state space. Nominal and real movements. Mathematical origin of non-stationarity. The problem of the existence of solutions of nonlinear differential equations of state. The problem of a unique solution. Rudolf Lipschitz's functions. Equilibrium states of nonlinear systems. Different properties of stability of the steady state. Invariant sets. The concept of the domain stability. Properties, types and graphic and analytic descriptions of nonlinearities. Features of nonlinear systems in the state space, input and output characteristics and peculiarities of the nonlinearities in the frequency domain. Symbolic operating computing. Rosenbrock's systems, Linear hypothesis. Lurie-Postnikov's systems, absolute stability, Aizerman's conjecture.

practical teaching

Practical training shall include computational auditory exercises with demanding mathematical apparatus that matters strictly follow the lectures and computer exercises which require knowledge of programming languages, "C", as well as knowledge and use of Matlab software package in order to interpret the nonlinearity computer and simulation to illustrate all features and all the phenomena of nonlinear systems. Stability testing of Lurie-Postnikov's and Rosenbrock's systems using Aizerman's conjecture and Linear hypotheses and determine the conditions in which these hypotheses can be applied.

prerequisite

Passed the examination in the subject for Automatic Control or Introduction to Automatic Control

learning resources

• Script on website: http://au.mas.bg.ac.rs/Nastava-Kau/Nastava_Download.htm
• Licensed Software in the possession of the Facultie.
• Freeware software.
• PCs.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 14
laboratory exercises: 11
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 5
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 4
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 6
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 55
laboratory exercises: 10
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

Ljubomir Grujic, Dragan Lazic, "Nonlinear Systems", Script, Faculty of Mechanical Eng., 2007

Nonlinear Systems 1

ID: MSc-0628
teaching professor: Јовановић Ж. Радиша
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: control engineering

goals

•Introduction to nonlinearities in the plants and processes.
•Introduction to basic concepts of analysis of nonlinear systems.
•Understanding and using the basic tools for testing the stability of nonlinear systems.
•Analysis of nonlinear systems using C and Matlab programming languages.

learning outcomes

Knowledge and understanding of:

•Nonlinear problems and phenomena in the processes and plants.
•Mathematical description of nonlinear systems.
•Basic methods for analyzing nonlinear systems in the time domain and state space.
•Simulation and analysis of nonlinear systems using a PC and programming languages C and Matlab.

theoretical teaching

Introduction to nonlinear systems and control. Typical nonlinear problems and phenomena. Types of nonlinearity.Types of nonlinear systems. State space. Solution of nonlinear dierential equations, existence and uniqueness of solutions, Lipschitz function, comparison principle. Equilibrium points. Phase-plane analysis: phase portrait, limit cycles, stability domain, classification of singular points.
Poincaré-Bendixson criterion. Lyapunov stability concepts. Lyapunov stability and instability theorems of equilibrium points. LaSalle's theorem, invariance principle and Chetaev’s theorem. Lyapunov’s direct and indirect methods. Krasovski's criterion.

practical teaching

PA:
Nonlinear mathematical models of dynamic systems. Determination of equilibrium points. Phase-plane analysis: phase portrait, limit cycles, stability domain, stability and attraction of equilibrium points. Determining the system stability by applying indirect and direct method of Lyapunov.

PL:
Application programming languages C and Matlab in the modeling, simulation and analysis of nonlinear systems. Practice and experiments: verification of non-linear mathematical models of different objects using a PC.

prerequisite

Defined by curriculum of the study programme.

learning resources

•Nonlinear systems 1 hands-out on: http://au.mas.bg.ac.yu/Nastava-Kau/Nastava_Download.html
•Computer control system, Automatic Control Laboratory, Faculty of Mechanical Engineering, Belgrade
•Freeware software.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 20
laboratory exercises: 10
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 4
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 6
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 50
laboratory exercises: 10
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

Hassan K. Khalil: "Nonlinear Systems", 3rd Edition, Prentice-Hall, 2002.

Nonlinear Systems 2

ID: MSc-0609
teaching professor: Јовановић Ж. Радиша
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: control engineering

goals

•Building the foundations of nonlinear control design and analysis.
•Introducing commonly used nonlinear control tools.
•Analysis and control of nonlinear systems using C and Matlab programming languages.

learning outcomes

Knowledge and understanding of:

•The basis of analysis of certain classes of nonlinear systems.
•The methods for testing the system stability by Lyapunov techniques and input-output analysis.
•The techniques of control of nonlinear systems.
•Simulation, analysis and control of nonlinear systems and sinthesis using programming languages C and Matlab.

theoretical teaching

Lurie's direct and indirect control systems. Linear and Aizerman Conjecture. Absolute stability. Popov's and Circle criteria. Tsypkin's trasnformation. Exact (feedback) linearization. Input-state linearization. input-output linearization. Zero dynamics and input-to-state stability. L2 gain and small gain theorem. Sliding mode control. Backstepping. Gain scheduling. Approximate methods. Describing function analysis. Modified Nyqiust criteria.

practical teaching

PA:
Practical work includes computational exercises that follow the content of course:
stability of Lurie direct and indirect systems; дегermination stability of nonlinear systems using linear and Aizerman conjecture; Popov's and circle criteria; exact (feedback) linearization: input-state linearization, input-output linearization; zero dynamics and input-to-state stability; sliding mode control: backstepping:gain scheduling; describing function analysis; modified Nyqiust criteria.

PL:
Application programming languages C and Matlab in the analysis, simulation and control of nonlinear systems.
Practice and experiments: control of nonlinear plants using various control techniques.

prerequisite

Defined by curriculum of the study programme.

learning resources

•Nonlinear systems 2 hands-out on: http://au.mas.bg.ac.yu/Nastava-Kau/Nastava_Download.html
•Computer control system, Automatic Control Laboratory, Faculty of Mechanical Engineering, Belgrade.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 20
laboratory exercises: 10
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 4
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 6
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 50
laboratory exercises: 10
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

Hassan K. Khalil: "Nonlinear Systems", 3rd Edition, Prentice-Hall, 2002.

Nonlinear Systems 2

ID: MSc-0103
teaching professor: Лазић В. Драган
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: control engineering

goals

Introduction to the fundamental theoretical results on nonlinear systems: a qualitative method of Lyapunov.
Mastery of quantitative methods for checking the stability of steady states, invariant sets, limit cycles.
Students learn to check the absolute stability using Popov's criteria.
Presentation of non-exact methods, their capabilities and limitations.

learning outcomes

The possibility of testing the system stability properties by the quantitative methods in the state space.
The general method for checking the stability of nonlinear systems whose only limit is the continuity of movement.
Capability for detailed analysis of a very large class of nonlinear systems such as Lurie's systems.
Competence for analyzes of the self-oscillatory system and defining feature of the stability of their own oscillations.

theoretical teaching

Testing the existence and character of limit cycles using Bendixson's criteria and Poincaré-Bendixson's criteria. Familiarisation with basic idea of Lyapunov for qualitative analysis of the system. General stability theorems: theorem of stability conditions, theorem of asymptotic stability conditions. Lyapunov matrix theorem. Krasovsky criteria: particular and general. Absolute stability. Jakubowicz Kalman lemma. The link between Popovljevog conditions and conditions in Jakubowicz Kalman form. Popov criterion. Geometric interpretation of Popov criteria. Cipkin's transformation. Approximate methods. Describing function method. Determination of the descriptive function of nonlinearity. Application of modified Nyquist criteria for testing character of the limit cycles.

practical teaching

Practical training shall include computational auditory exercises with the highly regarded mathematical apparatus that strictly follows the lectures and that concrete numerical examples and practices.
Methods for constructing the state state portrait. Isoline method of the phase portrait, Pell's method, Delta method. The study of singular point and defining Poincaré index of singular points. Determination of the time from the phase portrait. Positive/negative semidefinite and definite functions, radially unbounded functions, comparison functions. Limit values, Dini and Euler derivatives and total function derivatives.

prerequisite

Passed the examination of subject Nonlinear Systems 1 and nothing more

learning resources

• Script on website: http://au.mas.bg.ac.rs/Nastava-Kau/Nastava_Download.htm
• Licensed Software in the possession of the Facultie.
• Freeware software.
• PCs.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 25
laboratory exercises: 2
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 3
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 4
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 6
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 50
laboratory exercises: 0
calculation tasks: 15
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

Ljubomir Grujic, Dragan Lazic, "Nonlinear Systems", Script, Faculty of Mechanical Eng., 2007

Process identification

ID: MSc-0148
teaching professor: Дебељковић Љ. Драгутин
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: control engineering

goals

Student should be familiar with the basic ideas from identification and estimation theory, in order to be able to make a reconstruction of process model, based only on input - output measurements data collected over some period of time.
In that sense it is expected to recognize process structure, order of process model and to estimate unknown parameters of process.

learning outcomes

Contemporary methods of identification enables one to form mathematical models of different processes with much more accuracy than only based on analytical approach.
Moreover this procedure, when the real time control is used, enables so called adaptive control, which can perform all desire process characteristics and achieve practically all severe demands which, today, can be very often contradictory.

theoretical teaching

Object and process identification: Basic features and ideas. General questions and position of identification theory. Estimating theory. Classical identification methods. Parameter estimation. Parameter estimation of dynamical objects and processes. State estimation. Two point boundary problem. Invariant embedding. Quasi linearization. Simultaneously parameter and state estimation of dynamical objects and processes. Object and process structure identification. Some particular questions of identification.

practical teaching

Elements of estimating theory. Classical identifications methods: method based on step, impulse or sinusoidal response.Parameter estimation. Parameter estimation of dynamical objects and processes. Bayes estimation, maximum likelihood estimation, square method estimation. Kalman - Bucy time discrete filter. Simultaneously parameter and state estimation of dynamical objects and processes. Invariant embedding. Quasilinearization. Object and process structure identification. Some particular questions of identification.

prerequisite

It is expected that then exams from the following subjects are given: Automatic Control and Linear stochastic systems.

learning resources

D. Lj. Debeljkovic, Fundamentals of object and process identification, Faculty of Mechanical engineering, Belgrade 1987.

D. Lj. Debeljkovic, Identification of dynamical processes with lumped and distributed parameters, Faculty of Mechanical engineering, Belgrade 2010.

Habdouts.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 20
laboratory exercises: 0
calculation tasks: 0
seminar works: 6
project design: 4
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 2
check and assessment of projects: 4
colloquium, with assessment: 4
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 30
laboratory exercises: 0
calculation tasks: 0
seminar works: 20
project design: 10
final exam: 30
requirements to take the exam (number of points): 30

references

D. Lj. Debeljkovic, Fundamentals of object and process identification, Faculty of Mechanical engineering, Belgrade 1987.
Handouts

Process identification

ID: MSc-0678
teaching professor: Дебељковић Љ. Драгутин
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 4
final exam: written+oral
parent department: control engineering

goals

Student should be familiar with the basic ideas from identification and estimation theory, in order to be able to make a reconstruction of process model, based only on input - output measurements data collected over some period of time.
In that sense it is expected to recognize process structure, order of process model and to estimate unknown parameters of process.

learning outcomes

Contemporary methods of identification enables one to form mathematical models of different processes with much more accuracy than only based on analytical approach.
Moreover this procedure, when the real time control is used, enables so called adaptive control, which can perform all desire process characteristics and achieve practically all severe demands which, today, can be very often contradictory.

theoretical teaching

Object and process identification: Basic features and ideas. General questions and position of identification theory. Estimating theory. Classical identification methods. Parameter estimation. Parameter estimation of dynamical objects and processes. State estimation. Two point boundary problem. Invariant embedding. Quasi linearization. Simultaneously parameter and state estimation of dynamical objects and processes. Object and process structure identification. Some particular questions of identification.

practical teaching

Elements of estimating theory. Classical identifications methods: method based on step, impulse or sinusoidal response.Parameter estimation. Parameter estimation of dynamical objects and processes. Bayes estimation, maximum likelihood estimation, square method estimation. Kalman - Bucy time discrete filter. Simultaneously parameter and state estimation of dynamical objects and processes. Invariant embedding. Quasilinearization. Object and process structure identification. Some particular questions of identification.

prerequisite

It is expected that then exams from the following subjects are given: Automatic Control.

learning resources

D. Lj. Debeljkovic, Fundamentals of object and process identification, Faculty of Mechanical engineering, Belgrade 1987.

D. Lj. Debeljkovic, Identification of dynamical processes with lumped and distributed parameters, Faculty of Mechanical engineering, Belgrade 2010.

Handouts.

number of hours

total number of hours: 45

active teaching (theoretical)

lectures: 25

active teaching (practical)

auditory exercises: 6
laboratory exercises: 2
calculation tasks: 0
seminar works: 2
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 1
check and assessment of seminar works: 4
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 30
laboratory exercises: 10
calculation tasks: 0
seminar works: 20
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

D. Lj. Debeljkovic, Fundamentals of object and process identification, Faculty of Mechanical engineering, Belgrade 1987.
D. Lj. Debeljkovic, Identification of dynamical processes with lumped and distributed parameters, Faculty of Mechanical engineering, Belgrade 2010.

Professional practice M - CS

ID: MSc-0248
teaching professor: Лазић В. Драган
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 1
final exam: seminar works
parent department: control engineering

goals

Practical experience and students stay in the environment in which the student will realize his professional career.
Identifying the basic functions of the business system in the field of design, development and production, as well as the roles and tasks of mechanical engineering in such a business system.

learning outcomes

Students obtain practical experience on how the organization and functioning of the environment in which they will apply their knowledge in their future professional career. Student identifies models of communication with colleagues and business information flows. Student identifies the core processes in the design, manufacture, maintenance, in the context of his future professional competence. Establish the personal contacts and relationships that will be able to use at school or entering into future employment.

theoretical teaching

practical teaching

Practical work involves working in organizations that perform various activities in connection with mechanical engineering. Selection of thematic areas and industrial or research organizations conducted in consultation with the concerned teacher. In principle a student can perform in practice: production companies, design and consulting organizations, organizations concerned with maintaining mechanical equipment, public utility companies and some of the laboratories at Faculty of Mechanical Engineering. The practice may also be made abroad. During practice, students need to keep a diary in which to enter a description of operations performed, the conclusions and observations. Once completed practice must make a report to defend the subject teacher. The report is submitted in the form of the paper.

prerequisite

learning resources

number of hours

total number of hours: 46

active teaching (theoretical)

lectures: 0

active teaching (practical)

auditory exercises: 0
laboratory exercises: 0
calculation tasks: 0

seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 0
final exam: 46

assessment of knowledge (maximum number of points - 100)

feedback during course study: 70
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

professional practice m -SAU

ID: MSc-0369
teaching professor: Рибар Н. Срђан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 1
final exam: seminar works
parent department: control engineering

goals

Practical experience and introduction of the environment in which the student will realize his professional career. Identifying the basic functions of the business system in the field of design, development and production, as well as the roles and tasks of mechanical engineering in such a business system.

learning outcomes

Students get practical experience on the organization and functioning of the environment in which they will apply their knowledge in their future professional career. Student identifies models of communication with colleagues and business information flows. The student recognizes the basic processes in the design, manufacture, maintenance, in the context of his future professional competence. Establish the personal contacts and relationships that will be able to use during their education or entering into future employment.

theoretical teaching

practical teaching

Practical work involves working in organizations that perform various activities in connection with mechanical engineering. Selection of thematic areas and commercial or research organizations carried out in consultation with the concerned teacher. Generally a student can perform the practice in manufacturing organizations, project and consulting organizations, organizations engaged in mechanical equipment maintenance, and public utility companies and some of the laboratories at Faculty of Mechanical Engineering. Burst may also be made abroad. During practice, students must make a report to defend the subject teacher. The report is submitted in the form of the paper.

prerequisite

learning resources

number of hours

total number of hours: 48

active teaching (theoretical)

lectures: 0

active teaching (practical)

auditory exercises: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 1

project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 1
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 0
final exam: 46

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 90
project design: 0
final exam: 10
requirements to take the exam (number of points): 0

references

Project documentation

ID: MSc-0677
teaching professor: Лазић В. Драган
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: project design
parent department: control engineering

goals

Objective of the course is to introduce students to different stages of construction, from technical documentation preparation and obtaining the necessary approvals to construction and exploitation. Students learn about with the contents of the project. In the second part of the course acquire basic knowledge related to activities that follow design of processing industry facilities (power supply, operating fluids, transport, water flow etc.). Part of the course deals with the economic evaluation of investments.

learning outcomes

Main outcome of the course is to teach students to independently run object construction. This includes project documentation preparation and object construction. After successful completion of the study program, student is capable to foresee the extent of necessary design work in processing industry, as well as to plan necessary installation for production plants.

theoretical teaching

Legal framework for building facilities. Planning and Construction Law. Aim of design. Building capital investment facilities. Types of mechanical engineering projects. Content of a mechanical engineering project. Workplace safety. Fire protection. Environment protection. Assessment of impact on environment. Design of technology supported production line. Drawing schemes of technology systems and production systems. Marking of apparatus, valves, fittings and equipment for measuring and regulation on technological schemes. Technology warehouses and transport systems. Plants for energy supply. Basic forms of energy: heat (thermal), electrical and mechanical (potential and kinetic energy). Power systems. Operating fluids (water, air, technical gases).Distribution of water vapor. Compressed air and technical gases. Heating, air-conditioning and ventilation. Maintenance of production and technology systems. Assessment of services in building capital investment facilities. Investment costs. Feasibility study. Exploitation costs.

practical teaching

Introduction to the investment technical documentation. Introduction to the format of mechanical engineering projects. Examples of calculation of technology supported production lines. Examples of drawing technology systems schemes. Designing warehouses and transport systems. Power supply systems. Compressed air supply. Design of facilities for energy supply. Distribution of operative fluids. Budget and validation of investment. Exploitation and investment costs of facility operation. Independent realization of the main machine engineering project according to the predefined project task.

prerequisite

Defined with curriculum of study program / module

learning resources

Bogner M.: Design of thermotechnical and process systems, Third revised edition, Belgrade, 2007., KDA.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 20

active teaching (practical)

auditory exercises: 25
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 10
consultations: 5
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 5
colloquium, with assessment: 3
test, with assessment: 2
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 20
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 20
final exam: 50
requirements to take the exam (number of points): 30

references

Handouts
Perry's Chemical Engineering Handbook, Mc-Graw Hill, 1999.
Bogner M.: Design of thermotechnical and process systems, Third revised edition, Belgrade, 2007., KDA.

Signal Processing

ID: MSc-0535
teaching professor: Коруга Љ. Ђуро
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: control engineering

goals

Introduction of basic concepts and knowledge related to discrete signals and systems analysis in time domain as well as in frequent domain, digital processing of analog signals, digital processing of discrete and stochastic signals, digital filter design. Concerning digital image processing, student is introduced to concept of digital image, image quality enhancement, frequency domain processing, morphological processing and image compression.

learning outcomes

Student is provided with basic theoretical knowledge concerning digital signal and image processing for biomedical applications. Also during the course student is trained to actively use software such as MATLAB, with accompanied toolbox SIMULINK, for analysis and processing of 1-D and 2-D signals as well as for mathematical modeling of biological systems.

theoretical teaching

Discrete signal and system analysis in time domain: discrete signals and sequences and applied arithmetics, elementary signals, discrete signals, LTI systems, stability and causality of LTI systems, linear constants coefficient difference equations, block diagram representation of discrete systems. Discrete signals and systems analysis in frequency domain: Fourier transform, FTDS, DFT, FFT. Z-transform. Digital processing of continuous signals: continuous signal discretisation, A/D (D/A) conversion. IIR filters. FIR filters. Time discrete stochastic signals. Image formation, image quality enhancement, Fourier transforms and frequency domain processing, morphological processing, image segmentation and different methods of image compression. Neural network applications for signal and image processing.

practical teaching

Introduction to Matlab for digital signal and image processing. Import of various biomedical signals from PhysioBank data bank. Signal spectral analysis. ECG and EEG signal processing and analysis. Digital filter design. Introduction to SIMULINK. Biological systems modelling. Basics of image processing in Matlab. Medical image processing.Neural network applications for signal and image processing(Matlab).

prerequisite

Terms are defined by course curriculum.

learning resources

Auditory room equipped with computer, video beam, internet connection and accompanied inventory. Computer room with 30 computers with needed software installed.
[1] Handouts - lectures.
[2] Handouts - Auditory exercises.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 0
laboratory exercises: 25
calculation tasks: 5
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 4
check and assessment of projects: 0
colloquium, with assessment: 7
test, with assessment: 0
final exam: 4

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 40
laboratory exercises: 0
calculation tasks: 0
seminar works: 20
project design: 0
final exam: 30
requirements to take the exam (number of points): 40

references

I.Hut, B.Jeftić: Praktikum za vežbe iz obrade signala i slike, Beograd, 2011.
Lj. Milić, Z.Dobrosavljević: Uvod u digitalnu obradu signala, Akademska misao, Beograd, 2009.
Steven W. Smith, Ph.D.: The Scientists and Engineering's guide to Digital Signal Processing, ebook:http://www.dspguide.com/
M.Popović: Digitalna obrada slike, Akademska misao, Beograd, 2006.
C.Solomon, T.Breckon: Fundamentals of Digital Image Processing A Practical Approach with Examples in Matlab, Wiley-Blackwell, 2010.

Spectroscopy methods and techniques

ID: MSc-0654
teaching professor: Коруга Љ. Ђуро
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 2
final exam: written
parent department: control engineering

goals

Introducing students to fundamentals of spectroscopy methods and techniques. Through theoretical lectures and practical work student masters the understanding of light-matter interaction and how this interaction can be used to acquire information about structure of the matter. Through work on seminar paper and work in the laboratory student learns to apply acquired knowledge about structure of the matter in order to improve and control quality of various products in food industry, pharmacy, and other industrial branches, as well as in characterization of new materials, applications in biomedical engineering for early detection of bio-markers, pathological changes and diseases.

learning outcomes

Combining theoretical lectures and practical work in laboratory student learns to use modern spectroscopy equipment and different spectroscopy techniques. Through work on practical problems and seminar paper student get to know techniques of spectral data analysis in material characterization, food, medicines, and diagnostics of biological tissue samples in vitro and in vivo.

theoretical teaching

Introduction to Spectroscopy methods and techniques. Light – matter interaction. UV/VIS spectroscopy. UV/VIS spectra interpretation. Infra red spectroscopy. Multivariate analysis. IR spectra interpretation.Multivariate analysis applications on real spectral data. Raman spectroscopy. Fluorescence spectroscopy.Opto-magnetic spectroscopy. Applications of Raman and fluorescence spectroscopy Applications of opto-magnetic spectroscopy.

practical teaching

Working on seminar paper theme of specific case study in various areas of spectroscopy methods application. Practical laboratory work with UV/VIS and VIS/IR spectrometer: preparation and acquisition of spectra of water samples with different NaCl concentrations. Practical work with spectrofluorometer : acquisition of spectra of the normal skin and skin with anomalies, using SPEX SKIN SKAN spectrofluorometer. Practical work with opto-magnetic apparatus: capturing digital images of the normal and anomalous skin in white and polarized white light, digital image processing, spectral convolution in MATLAB, spectral data analysis using Excel and The Unscrambler. Multivariate methods application: principal component analysis, soft modeling of class analogies, partial least squares regression; analysis of the spectral data acquired in laboratory. Basic softwares for multivariate analysis : The Unscrambler, Pirouette, MATLAB - statistic toolbox.

prerequisite

Defined by the curriculum of the study module Biomedical engineering

learning resources

1. Written course material (handout)
2. Scientific articles (KOBSON) - University network is available on laboratory computers (Nanolab) and cabinet 300
3. MATLAB, The Unscrambler, Pirouette - sofwares available in full or trial version
4. UV/VIS, VIS/IR Hamamatsu spectrometers, Opto-magnetic apparatus, SKIN-SKAN spectrofluorometer - instruments are available in laboratory of Biomedical Engineering department - Nanolab

number of hours

total number of hours: 30

active teaching (theoretical)

lectures: 11

active teaching (practical)

auditory exercises: 3
laboratory exercises: 3
calculation tasks: 0
seminar works: 4
project design: 0
consultations: 1
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 3
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 3
final exam: 2

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 45
laboratory exercises: 0
calculation tasks: 0
seminar works: 15
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

Larkin, P., Infrared and Raman Spectroscopy: Principals and Spectral Interpretation, Elsevier, 2011.
Lindon, J., Tranter, G., Holmes, J., Encyclopedia of Spectroscopy and Spectrometry, Elsevier, 2000.
Koruga, Dj., Tomić, A., System and Method for Analysis of Light-matter Interaction Based on Spectral Convolution, US Patent Pub. No.: 2009/0245603, Pub. Date: Oct. 1, 2009
Graham Solomons, T. W., Fryhle, C., Organic Chemistry, John Wiley and Sons, 2011.
Kelter, P., Mosher, M., Scott, A., Chemistry: The Practical Science, Houghton Mifflin Company, 2009.

Stochastic Linear Systems

ID: MSc-0679
teaching professor: Дебељковић Љ. Драгутин
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 2
final exam: written+oral
parent department: control engineering

goals

To be familiar with the knowledge of stochastic, ergodic random processes and with the methods for control system analysis and design in time and frequency domain.
Based on essential stochastic signal characteristics to be able to estimate fundamental system behavior, when random processes are present on the inputs of the system.
To able to implement some of optimization techniques in such cases.

learning outcomes

To be familiar, to introduce as well basic principle of contemporary probability theory and mathematical statistics and all of that to implement to linear continuous time invariant automatic control systems, when they are subjected to the influence of random signals.
To be capable to implement for direct implementation of different control strategies.

theoretical teaching

Some basic knowledge from probabilistic theory.
Random variables.
Stochastic processes.
Linear system analysis in time domain.
Linear system analysis in frequency domain.
Linear system design based on mean square error.
Linear system design in time domain.
Linear system design in frequency domain.

practical teaching

Filtering, interpolation, prediction.
Stochastic processes.
Linear system analysis in time domain.
Linear system analysis in frequency domain.
Linear system design based on mean square error.
Linear system design in frequency domain.
Viener - Hoppf equation.
Bode- Shanons method.

prerequisite

Given exams from subjects : Automatic Control.

learning resources

D.Lj.Debeljković, “Linear Stochastic Control Systems”, Science book, Belgrade, 1985, Second ed. Faculty of Mechanical Engineering, Belgrade 1992, pages 257.

D. Lj. Debeljkovic, Analysis, Synthesis and Estimation of Linear Control Systems in the Presence of Random Signals, Faculty of Mechanical Engineering, Belgrade, 2010 (in Serbian), pp. 444, ISBN 978 – 86 – 7083 – 683 – 9.

Handouts

number of hours

total number of hours: 30

active teaching (theoretical)

lectures: 20

active teaching (practical)

auditory exercises: 4
laboratory exercises: 0
calculation tasks: 0
seminar works: 2
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 4
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 0
final exam: 0

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 30
laboratory exercises: 0
calculation tasks: 0
seminar works: 30
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

D.Lj.Debeljković, “Linear Stochastic Control Systems”, Science book, Belgrade, 1985, Second ed. Faculty of Mechanical Engineering, Belgrade 1992, pages 257.
D. Lj. Debeljkovic, Analysis, Synthesis and Estimation of Linear Control Systems in the Presence of Random Signals, Faculty of Mechanical Engineering, Belgrade, 2010 (in Serbian), pp. 444,

Student practice M - BME

ID: MSc-0233
teaching professor: Коруга Љ. Ђуро
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 1
final exam: seminar works
parent department: control engineering

goals

Practical experiences, and work in environment where student will realize his/her professional career.
Identifying the basic functions of the working system in the field of design, development and production, as well as the roles and tasks of mechanical engineering in such a working system.

learning outcomes

Students get practical experience in organization and functioning of the environment in which they will apply their knowledge in the future professional career.
Student identifies models of communication with colleagues and business information flows.
Student recognizes the basic processes in the design, manufacture, maintenance, in the context of his future professional competence.
Personal contacts will be establish the and connections that they will be able to use during their studying, or by entering into future employment.

theoretical teaching

practical teaching

Practical work embrace all the activities in the organizations where are done different activities connected with mechanical engineering.
Choosing the thematic unit and organization is done in consultation with professor.
Student may do practical work in: manufacturing organizations, constructional and consulting organizations, organizations which are dealing with maintenance of machine equipment, and public utility companies and in some of the laboratories at Faculty of Mechanical Engineering.
The practice may also be made abroad.
During practice, students must keep a diary in which they write descriptions of the performed tasks, the conclusions and observations.
After finished practice students must make a report which they will justify to the subject teacher. The report is submitted in the form of the paper.

prerequisite

Done practice and written diary of the activities.

learning resources

number of hours

total number of hours: 46

active teaching (theoretical)

lectures: 0

active teaching (practical)

auditory exercises: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 0
final exam: 46

assessment of knowledge (maximum number of points - 100)

feedback during course study: 70
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

Object and process dynamics

ID: MSc-0126
teaching professor: Дебељковић Љ. Драгутин
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: control engineering

goals

Student should be familiar with basic principle and steps of mathematical modeling of objects and processes. To be capable to form basic balance equations which describes non-stationary states of objects and processes which, after suitable choice of state variables, manipulated and control variables as well as disturbances variables enables one to form adequate and non-unique state space representations of objects and processes for the needs of further analyzing or synthesis.

learning outcomes

To be familiar and to be capable to use the basic principle of mathematical modeling applied to: dynamics of material handling, flow processes, flow-thermal processes, machine dynamics, traffic and transportation dynamics and contemporary plants existing in area of general energetic. Moreover it is expected to be capable to perform elementary analysis of their transient response characteristics from the above mentioned list of objects and processes.

theoretical teaching

Mathematical modeling of objects and processes - general approach. Ideas, rules, conditions , limitations and use of models. Kinematics and dynamics of materials handling. Fluid in motion - Dynamics of flow processes. Thermal-flow dybnamics. Mass transfer dynamics Heat exchangers dynamics. Machine and motor dynamics. Dynamics of traffic and transportation processes. Aerospace dynamics. Ship dynamics. Energetic plant dynamics. Steam generator dynamics. Dynamics of hydraulic turbines within the overall hydraulic power station. Nuclear power station dynamics. Forming, propulsion and guidance dynamics. Chemical process dynamics.

practical teaching

Level system dynamics. The mathematical model of incompressible flow throughout the long pipes. The mathematical model of compressible flow process througout the classical reservoir with two valves. Model of rigid and elastic water shock. Floor heating process. Temperature distribution within the closed room without and with air circulation. Steam generator model and dynamics. Model of nuclear power plant - discussion.The mathematical model of gas turbine plant- model and discussions.
Analysis of elementary chemical processes.
Laboratory work: Level systems dynamics. Transportation process and the process of storage, holdup and inventory systems. Heat exchangers dynamics.

prerequisite

Exams from the following subjects should be given: All Mechanics, Thermodynamics and Fluid mechanics.

learning resources

D. Lj. Debeljkovic, G. V. Simeunovic, “Dynamics of Processes – Mathematical Model of Plants and Processes in Control Engineering”, Faculty of Mechanical Engineering, Belgrade, 2006.

D. Lj. Debeljkovic, A. M. Sicovic G. V. Simeunovic, V. S. Mulic, Dynamics of Processes – Mathematical Model of Plants and Processes in Control Engineering, Part II Faculty of Mechanical Engineering, Belgrade, 2006.

D. Lj. Debeljkovic, D. T. Stojiljkovic, G. V. Simeunovic, A. M. Sicovic, V. S. Mulic, Dynamics of Processes – Mathematical Model of Plants and Processes in Control Engineering, Part IV – Dynamics of Large - Scale Industrial Plants and Processes, Faculty of Mechanical Engineering, Belgrade, 2008,
pp. 470.
D. Lj. Debeljkovic, G. V. Simeunovic, A. M. Sicovic, Dynamics of Processes – Mathematical Model of Plants and Processes in Control Engineering, Part V,
Faculty of Mechanical Engineering, Belgrade, 2008, pp. 450.

D. Lj. Debeljkovic, , G. V. Simeunovic, Dynamics of Processes – Mathematical Model of Plants and Processes in Control Engineering, Part VI, Faculty of Mechanical Engineering, Belgrade, 2009, pp. 445.

D. Lj. Debeljkovic, G. V. Simeunovic, Lj. A. Jacic, Dynamics of Processes – Mathematical Model of Plants and Processes in Control Engineering, Part VII,
Faculty of Mechanical Engineering, Belgrade, 2009, pp. 446.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 16
laboratory exercises: 4
calculation tasks: 0
seminar works: 6
project design: 4
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 4
check and assessment of seminar works: 2
check and assessment of projects: 0
colloquium, with assessment: 4
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 30
laboratory exercises: 0
calculation tasks: 0
seminar works: 20
project design: 10
final exam: 30
requirements to take the exam (number of points): 35

references

D. Lj. Debeljkovic, G. V. Simeunovic, “Dynamics of Processes – Mathematical Model of Plants and Processes in Control Engineering”, Faculty of Mechanical Engineering, Belgrade, 2006.
D. Lj. Debeljkovic, A. M. Sicovic G. V. Simeunovic, V. S. Mulic, Dynamics of Processes – Modelibnfg of Plants and Processes in Control Engineering, Part II Faculty of Mech. Eng, 2006.
D. Lj. Debeljkovic, Solved problems in modeling od dynamics of objects and process, Mechanical faculty, Belgrade, 1990.
D. Lj. Debeljkovic, G. V. Simeunovic, A. M. Sicovic, Dynamics of Processes – Mathematical Model of Plants and Processes in Control Engineering, Part V, Faculty of Mech. Eng, , 2008, pp. 450.
Handouts

ID: MSc-0583
teaching professor: Рибар Б. Зоран
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: control engineering

goals

learning outcomes

theoretical teaching

practical teaching

prerequisite

learning resources

number of hours

total number of hours: 0

active teaching (theoretical)

lectures: 0

active teaching (practical)

auditory exercises: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 0
final exam: 0

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0

final exam: 0
requirements to take the exam (number of points): 0

references

ID: MSc-0641
teaching professor: Ристановић Р. Милан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 1
final exam: project design
parent department: control engineering

goals

Practical experiences, and work in environment where student will realize his/her professional career.
Identifying the basic functions of the working system in the field of design, development and production, as well as the roles and tasks of mechanical engineering in such a working system.

learning outcomes

Students get practical experience in organization and functioning of the environment in which they will apply their knowledge in the future professional career.
Student identifies models of communication with colleagues and business information flows.
Student recognizes the basic processes in the design, manufacture, maintenance, in the context of his future professional competence.
Personal contacts will be establish the and connections that they will be able to use during their studying, or by entering into future employment.

theoretical teaching

practical teaching

Practical work embrace all the activities in the organizations where are done different activities connected with mechanical engineering.
Choosing the thematic unit and organization is done in consultation with professor.
Student may do practical work in: manufacturing organizations, constructional and consulting organizations, organizations which are dealing with maintenance of machine equipment, and public utility companies and in some of the laboratories at Faculty of Mechanical Engineering.
The practice may also be made abroad.
During practice, students must keep a diary in which they write descriptions of the performed tasks, the conclusions and observations.
After finished practice students must make a report which they will justify to the subject teacher. The report is submitted in the form of the paper.

prerequisite

learning resources

number of hours

total number of hours: 46

active teaching (theoretical)

lectures: 0

active teaching (practical)

auditory exercises: 0
laboratory exercises: 0

calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 0
final exam: 46

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 100
requirements to take the exam (number of points): 0

references

engineering materials and welding, tribology, fuels and combustion

Assurance and quality control of welded joint
Basic of welding M
Biofuels in combustion processes
Biomaterials in Medicine and Dentistry
Combustion
Combustion and Sustainable Development
Ecology of Combustion
Engineering materials 3
Finite element method
Finite element method 2
Fuel, Lubricants and Industrial Water 2
Professional practice M-WWS
Service Properties of Welded Joints
Specialized joining techniques
Structural integrity
Tribological systems
Tribology
Tribotechnique
Welding technology procedure

Assurance and quality control of welded joint

ID: MSc-0720
teaching professor: Ђукић З. Милош
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: engineering materials and welding, tribology, fuels and combustion

goals

The aim of this course is for students to become competent in the area of assurance and quality control of welded joints and welded constructions. They should also develop appropriate academic skills and creativity and master practical skills needed for the profession. This course is designed to provide information through theoretical lectures but also through laboratory type (practical) exercises, computational classes and seminar papers students are responsible for writing.

learning outcomes

Widespread application of the continuous development in the field of welding pointed to the forefront the importance of engineers responsible for implementing the growing need for assurance and control of weld quality. In addition, modern techno-economic approach in production and the need for constant lowering costs of welded structures carries a tendency of lowering the level of security and use a lot more economical and less conservative approach in the design of welded structures, which additionally foregrounds the importance of assurance and quality control of welded joint at all stages.After fulfilling all the course requirements, a student is capable to: plan, define and coordinate welded joints evaluation program, as well as to conduct procedures and solve concrete problems in the area of inspection and quality assurance inspection and control of welded joints and welded contructions. Throughout this course students would also develop the ability to combine aquired knowledge with the knowlede in other areas of material and engineering sciences and to apply it to practical problems.

theoretical teaching

The concept and importance of the quality of welded construction. Quality assurance (QA) and quality management (QM) of welding construction. Quality requirements for fusion welding of metallic materials. Welded joint defects/imperfection. Causes of defects. Clasification of defects and analysis of different types of defects. Fusion welding and allied processes - classification of geometric imperfections in metallic materials. Typical forms and causes of certain types of welded joint defect. Quality assurance and inspection of welds and welded construction. Welding coordination - tasks and responsibilities. Welding quality control plan. Qualification test of welders - fusion welding. The procedure for design of welded construction. Specification and qualification of welding procedures for metallic materials. Weld cracking, classification, main causes. The methodological approach to the analysis of weld cracking. Hot Cracks. Cold cracks. Lamellar tearing. Weld post weld heat treatment cracks. Fusion welding – quality level for imperfection. Levels of quality assurance. Nondestructive Evaluation of welded joint and quality control.

practical teaching

Recapitulation - welded joints basic types, elements, forms of and marking. Clasification of welded joint defects. Practical examples of welded joint defects. Analysis of macro and microstructure of welded joints. Preparation of Welder qualificitaion certificate. Preparation of welding procedure specification (WPS). Preparation of welding procedure qualification record (WPQR). Fusion welding – quality level for imperfection (practical exercises). Exercises in welding shop – welded joint defects analysis. Characterization of welded joints. Fusion welding - quality level for imperfection. Assessment of imperfections. Acceptance criteria for welds and examination methods for evaluating weld. Influence of welding shape defects, lack of fusion and other defects onto appearance of damage of welded joints. Office hours.

prerequisite

Necessary conditions for a student to attend this course are: attended course lectures and finished exercises of Engineering materials 2.

learning resources

1. А.Седмак, В. Шијачки Жеравчић, А. Милосављевић, В. Ђорђевић, М. Вукићевић, Машински материјали, други део, Машински факултет, Београд, 2000
2. В. Шијачки Жеравчић, А. Милосављевић, А. Седмак, Приручник за машинске материјале - заваривање, лемљење и ливење, Машински факултет, Београд, 1996

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 0
laboratory exercises: 8
calculation tasks: 7
seminar works: 10
project design: 0
consultations: 2
discussion and workshop: 3
research: 0

knowledge checks

check and assessment of calculation tasks: 1
check and assessment of lab reports: 1
check and assessment of seminar works: 2
check and assessment of projects: 0
colloquium, with assessment: 2
test, with assessment: 4
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 35
laboratory exercises: 10
calculation tasks: 5
seminar works: 15
project design: 0

final exam: 30
requirements to take the exam (number of points): 40

references

ASM Metals HandBook Volume 06 - Welding Brazing and Soldering v1, 1993
ASM Metals HandBook Volume 17 - Nondestructive Evaluation And Quality Control v3, 1998
ASM Metals HandBook Vol 08 - Mechanical Testing and Evaluation, 2000

Basic of welding M

ID: MSc-0525
teaching professor: Прокић-Цветковић М. Радица
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: engineering materials and welding, tribology, fuels and combustion

goals

The aim of this course is for students to become competent in the area of welding. This course is designed to provide information through theoretical lectures, computational classes and seminar papers, but also through welding workshop practice. They should also develop appropriate academic skills needed for the profession and become informed with the specificity of each welding process and appropriate equipment.

learning outcomes

After fulfilling all the course requirements, a student is capable to solve concrete problems in the area of Basic of welding M using aquired knowledge, as well as to comprehend possible consequences of the proposed solution. Throughout this course students would also develop the ability to combine aquired knowledge with other areas of material and engineering sciences and to apply it to practical problems.

theoretical teaching

Introduction. Physical basic of welding. Conventional welding processes. Welding metallurgy of steel. Cracking in welded joints. Structural changes in welded joints. CCT diagrams and heat treatment of welded joints. Thermal processes in welding. Residual stresses and distortions in welds. The weldability and quality control of welded joints. Welding of various steel. Welding of non-ferous metals.

practical teaching

Symbolic representation of welds on drawings. Structural changes in welded joints. Weldability by calculation of the equivalent carbon content. Discontinuities in welded joints. Welding of alloyed steel. Calculation of chrome equivalent and nickel equivalent. Welding of certain non-ferous metals and iron. Surface welding, metallization, brazing and sticking. Special welding processes. Calculation of consumption of electrodes. Practice in the welding workshop. Equipment for arc welding processes. Equipment for resistance welding, gas welding and cutting. Consultations.

prerequisite

Engineering materials 1 and Engineering materials 2

learning resources

1. A Sedmak, V. Sijacki Zeravcic, A. Milosavljevic, V. Djordjevic, M. Vukicevic, Engineering materials, second part, Faculty of Mechanical Engineering, Belgrade, 2000.
2. V. Sijacki Zeravcic, A. Milosavljevic, A Sedmak, Manual for Engineering materials – Welding, Brazing and Casting, Faculty of Mechanical Engineering, Belgrade, 1996.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 20

active teaching (practical)

auditory exercises: 9
laboratory exercises: 8
calculation tasks: 4
seminar works: 14
project design: 0
consultations: 2
discussion and workshop: 3
research: 0

knowledge checks

check and assessment of calculation tasks: 1
check and assessment of lab reports: 1
check and assessment of seminar works: 2
check and assessment of projects: 0
colloquium, with assessment: 2
test, with assessment: 4
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 35
laboratory exercises: 10
calculation tasks: 5
seminar works: 15
project design: 0
final exam: 30
requirements to take the exam (number of points): 40

references

K. Weman, Welding Procces Handbook, Woodhead Publishing Ltd, 2003.
G. Mathers, The welding of aluminium and its alloys, Woodhead Publishing Ltd, 2002.
D. Geary, Welding, The McGraw-Hill Companies, 2000.
S. Kou, Welding Metallurgy- second edition, John Wiley & Sons, 2003.

Biofuels in combustion processes

ID: MSc-0625
teaching professor: Стојиљковић Д. Драгослава
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: engineering materials and welding, tribology, fuels and combustion

goals

Types of biofuels and their classification. Characterization of solid, liquid and gaseous biofuels. Modern procedures of analysis and characterization. Biofuels standardization. Solid, liquid and gaseous biofuels - modern procedures of production and application. Importance of biofuels from the environmental point of view, sustainability criteria. Basics of calculations of combustion process and pollutant emissions. Phases of combustion and basics of modeling. Modern systems for biofuels combustion. Possibilities for utilization of mixtures of biofuels and fossil fuels in the combustion processes. Future development of biofuels.

learning outcomes

Acquisition of basic knowledge of biofuels, their types and properties, and methods of production. Mastering the basic methods of characterization of biofuel and engineering calculations of combustion process. Acquiring knowledge about modern and specific methods of biofuels characterization. Introduction to the raw materials for the production and methods of production and application. Basic knowledge about the preparation of biofuels for the combustion process, the specific characteristics of individual phases of combustion, classification of combustion equipment. Acquiring knowledge about the the environmental impact of biofuels. Understanding the positive experiences in the application of biofuels.

theoretical teaching

Biofuels (pellets, briquettes, wood chips, bioethanol, biodiesel, biogas etc.) and basic characteristics. Specific characteristics of biofuels related to the fossil fuels. Raw materials and production methods. Possibilities for biofuels utilization (stoves, boilers, IC engines). Influence of biofuels characteristics on selection of the best available technology for combustion. Calculation of the combustion process and phases of biofuels combustion. Modern equipment for biofuels combustion. Biofuels and environment.

practical teaching

Basics of biofuels characterization and specific characteristics related to the fossil fuels. Characterization of solid fuels. Recalculation from one to another mass basis for solid biofuels. Characterization of liquid biofuels. Characterization of gaseous biofuels. Determination of biofuels heating value, calculation method and experimental method. Elements of stoichiometry and determination of pollutants emission from combustion process. Determination of physical and chemical characteristics of the liquid biofuels. Basics of modeling of biofuels combustion process. Basics of measurements in modern combustion systems for biofuels combustion.

prerequisite

No special requirements.

learning resources

Loo S., Koppejna J.: The Handbook of Biomass Combustion & Co-firing, Earthscan, 2007; Rutz D., Janssen: BioFuel Technology Handbook, Intelligent Energy Europe, 2007.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 8
laboratory exercises: 18
calculation tasks: 4
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 1
check and assessment of lab reports: 3
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 1
test, with assessment: 5
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 40
laboratory exercises: 10
calculation tasks: 5
seminar works: 0
project design: 0
final exam: 40
requirements to take the exam (number of points): 30

references

Biomaterials in Medicine and Dentistry

ID: MSc-0640
teaching professor: Седмак С. Александар
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: engineering materials and welding, tribology, fuels and combustion

goals

Introducing students to the application of different biomaterials, previously discussed during Foundations of Biomaterials course, in order to understand and study functional behaviour of biomaterials in the human body. Analysis of the connections between the biomaterial and the body system, in order to ensure reliable implant operation. The potential co-operation with experts in the field of materials science, dentistry and medicine is allowed, which provides the ability to work in specialized laboratories and clinical facilities.

learning outcomes

By attending this course the student will master the application of biomaterials in medicine and dentistry, using modern scientific methods. Theoretical considerations, laboratory experimental work and the application of numerical analysis using the licensed software for finite element method, enables the synergy of the previously acquired knowledge in physics, materials science, mathematics and mechanics, in order to implement them in engineering practice.

theoretical teaching

Application of biomaterials in medicine and dentistry. Fundamentals of making implants in the human body. Compounding biomaterials and achieving biocompatibility. Problems of contact surfaces in designing the structure of biomaterials in the human body. The problems of various physical, chemical and mechanical properties of combined materials. Damage of biomaterials during the exploitation: wear, corrosion and fatigue of biomaterials, corrosion under stress, cracking. Biocomposite materials; achieving a gradual change in material properties in the compound (functionally graded materials FGM). Thin coatings and nanostructured biomaterials. New alloys in biomedical applications. Testing of biomaterials. Lifetime and structural integrity assurance of biomaterials: analytical, numerical and experimental methods. Prevention of failure of the biomaterials structure (case studies).

practical teaching

Examples of applications of biomaterials in the design, development and exploitation of structures used in medicine and dentistry. Examples and solutions of implants that are made from biomaterials, known from the Biomaterials 1 course. Experimental Methods In Vitro and In Vivo. Application of analytical and numerical models in the structural integrity assurance of biomaterials. Development of a model using the finite element method. Calculation examples considering problems in designing connecting surfaces in biomaterial structures. Application of configuration forces method to prevent failure of the biomaterials structures.

prerequisite

required:Foundations of Biomaterials ; desirable: Foundations of biomedical engineering and Biophysics

learning resources

[1] Written lessons from lectures (handouts)
[2] A. Sedmak, M. Rakin, Biomaterials - compounds and problems of the connecting surfaces, Belgrade 2011 (script in preparation)
[3] T. Nenadovic, Stainless Materials, BIGZ, Belgrade, 2001
[4] ABAQUS User's Manuals, Hibbit, Karlsson & Sorensen, Abaqus Inc., Version 6.5 and upgrades 2005-2007
[5] M. Rakin, A. Sedmak, B. Medjo, M. Dobrojević, Solved examples of using the software package ABAQUS in engineering materials, course materials in preparation for 2011

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 10
laboratory exercises: 8
calculation tasks: 5
seminar works: 0
project design: 4
consultations: 3
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 3
check and assessment of seminar works: 0
check and assessment of projects: 4
colloquium, with assessment: 2
test, with assessment: 1
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 20
laboratory exercises: 20
calculation tasks: 0
seminar works: 0
project design: 20
final exam: 30
requirements to take the exam (number of points): 40

references

J.B. Park and R.S. Lakes. Biomaterials An Introduction. Plenum Press, New York, 1992.
I.Milne, R.O. Ritcie, B. Karihaloo. Comprehensive Structural Integrity, Vol. 9: Bioengineering. Elsevier Ltd, Oxford, 2003.
D. M. Brunette, P. Tengvall, M. Textor, P. Thomsen, Titanium in Medicine, Springer, Berlin, 2001.
T.L. Anderson, Fracture Mechanics: Fundamentals and Applications 3rd ed. CRC Press, London, 2005.
M. Kojić, N. Filopović, B. Stojanović, N. Kojić, Computer Modeling in Bioengineering. John Wiley and Sons, Ltd (2008)

Combustion

ID: MSc-0351
teaching professor: Стојиљковић Д. Драгослава
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: engineering materials and welding, tribology, fuels and combustion

goals

Fundamentals of thermodynamics of the combustion process, general terms, material and energy balance of the process. Fundamentals of chemical statics and kinetics of thermal processes. Physical and physical-chemical phenomena in the combustion process. Specific features of combustion of solid, liquid and gaseous fuels. Combustion appliances. Environmental aspects of combustion.

learning outcomes

Mastering the techniques of calculation of material and energy balance of the combustion process. Mastering the techniques of flame investigation. Acquiring knowledge on the control of the combustion efficiency. Acquiring knowledge about the impact of combustion products on the environment.

theoretical teaching

Fundamentals of thermodynamics of the combustion process, general terms, material and energy balance of the process. Fundamentals of chemical statics and kinetics of thermal processes. Chemical equilibrium, the speed of chemical reactions. Physical and physical-chemical phenomena in the combustion process. The phenomena of ignition and self-ignition. Specific features of combustion of solid, liquid and gaseous fuels. Combustion appliances for different fuels. Environmental aspects of combustion. The causes, mechanisms of toxic components and the possibility of prevention. The measures and procedures for reduction of toxic emissions.

practical teaching

Chemical kinetics, chemical equilibrium problem solving and speed of chemical reactions in combustion. Dissociation products of combustion, the calculation of the amount and composition of the products of combbustion and combustion temperature. Incomplete combustion, determination of the amount and composition of the products of combustion and combustion temperature. Length of laminar flames, influential properties, experimental determination. The boundaries of stable combustion, the definition and experimental determination. Ignition limits (concentrations). Flame front propagation speed.

prerequisite

No special requirements.

learning resources

Milan Radovanovic: Fuels; Milan Radovanovic: Industrial water; Aleksandar Rac: Lubricants; D. Draskovic, M. Radovanovic, M. Adzic: Combustion; M. Adzic, A. Rac, S. Memetović: Manual for laboratory exercises in the Fuels, M. Radovanovic: Manual for laboratory exercises in the combustion

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 8
laboratory exercises: 20
calculation tasks: 2
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 2
check and assessment of lab reports: 3
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 5
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 40
laboratory exercises: 10
calculation tasks: 5
seminar works: 0
project design: 0
final exam: 40
requirements to take the exam (number of points): 30

references

D. Draskovic, M. Radovanovic, M. Adzic: Combustion
M. Radovanovic: Manual for laboratory exercises in the combustion
Milan Radovanovic: Fuels
M. Adzic, A. Rac, S. Memetović: Manual for laboratory exercises in the Fuels

Combustion and Sustainable Development

ID: MSc-0570
teaching professor: Аџић М. Мирољуб
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: engineering materials and welding, tribology, fuels and combustion

goals

At the moment 75% of the world's energy consumption is produced by combustion and it is expected that combustion will be a prevailing method for energy production in the coming decades with still over 65% high. The goal of this subject is to involve students into problems of sustainable development and energy, enable better understanding, accept the new knowledge and teach them how to take part in solving these key development problems.

learning outcomes

To familiarize each student with modern and future challenges of new scenario problem of energy and sustainable development

To enable students to understand the topic at the level which will enable them to understand and judge various techniques of combustion in existing and new energy systems and technologies,

To enable students to apply the acquired knowledge in industry and energy production systems,

To get strong background for further extension of knowledge in the area of research and developments

theoretical teaching

Problems of energy. Energy resources.
Fossil fuels, renewables, industrial and communal waste.
Ecology – air, water and soil pollution.
Combustion basics. Conservation of mass and energy.
Energy and combustion.
Combustion characteristics of different fuels.
The environmental impact of combustion.
Concept of sustainable development.
Complex systems.
Sustainable development of industrialized countries.
Specific problems of developing countries.
New technologies.

practical teaching

Practical tuition includes analysis and examples of conservation of mass and energy laws regarding combustion and emissions, as well as, principles of emission measurements. Measurements of flue gas emission components will be performed in a purpose built test stand. A student will theoretically and numerically solve problems of mass and energy balance of a particular fuel.

The work will also include case analysis of introduction of alternative fuel, more favorable regarding sustainable development, into a particular energy utility plant or process.

prerequisite

Thermodynamics B exam passed

learning resources

Subject Handouts.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 10
laboratory exercises: 5
calculation tasks: 5
seminar works: 5
project design: 0
consultations: 5
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 5
check and assessment of projects: 0
colloquium, with assessment: 5
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 30
laboratory exercises: 10
calculation tasks: 0
seminar works: 20
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

M. Adžić, Subject handouts
Energy for Sustainable World, N. Đajić, Faculty of Mining and Geology, Belgrade
Combustion, D. Drasković, M. Radovanović and M. Adžić, Faculty of Mechanical Engineering Berlgrade
Fuels, M. Radovanović, Faculty of Mechanical Engineering Berlgrade
Principles of Combustion, Kenneth K. Kuo, BARNES & NOBLE:

Ecology of Combustion

ID: MSc-0555
teaching professor: Аџић М. Мирољуб
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: engineering materials and welding, tribology, fuels and combustion

goals

More than 75% of the world's energy consumption is produced by combustion. It is expected that combustion will still be a prevailing method for energy production in the coming decades. On the other hand, having in mind that combustion is by far the biggest source of pollution, the goal of subject is to enable better understanding of the topic, train and qualify students to become competent experts in this field of international key importance.

learning outcomes

To familiarize each student with modern combustion technologies, particularly and in detail with the problem of emissions of polluting and harmful components and modern methods for pollution prevention and control, to enable students to apply thus gained knowledge in industry and energy production areas, as well as, to get strong background for further extension of knowledge in the area of research and developments.

theoretical teaching

Combustion basics.Conservation of mass and enery.
Specific topics on combustion of different fuels.
Combustion facilities and their performance.
Biofules.
Co-combustion.
Emissions of polluting and harmful contaminants.
Role of CO_2.
Technics to reduce emission of NO_x.
Technics to reduce emission of SO_2.
Technics to reduce emission of CO and HC.
Technics to reduce emission of particulates.
Technics to reduce emission of heavy metals
Technics to reduce emission of CO_2.
CO_2 trading.
New technologies. Fuel cells. Hydrogen.

practical teaching

Practical tuition includes analysis and examples of conservation of mass and enery laws regardding combustion and emissions. Examples of technics to reduce emissions of NO_x and SO_2 will be treated in particular. Measurements of flue gas emission components will be performed in a purpose built test stand. The effect of influencing parameters on emission performance of a purposely built burner will be experimentally performed and analyzed. A student will theoretically and numerically solve a problem of mass and energy balance of one of pollution reduction techniques.

prerequisite

Thermodynamics B exam passed

learning resources

Subject Handouts

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 10
laboratory exercises: 10
calculation tasks: 5
seminar works: 0
project design: 0
consultations: 5
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 5
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 5
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 30
laboratory exercises: 10
calculation tasks: 20
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

M. Adžić, Subject handouts
Combustion, D. Drasković, M. Radovanović and M. Adžić, Faculty of Mechanical Engineering Berlgrade
Principles of Combustion (Принципи сагоревања), Kenneth K. Kuo, BARNES & NOBLE:

Engineering materials 3

ID: MSc-0267
teaching professor: Шијачки Жеравчић М. Вера
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 4
final exam: written+oral
parent department: engineering materials and welding, tribology, fuels and combustion

goals

The aim of this course is to introduce students to different types of engineering materials and their properties with the goal of understanding and studying the possibility of their application for manufacturing of different elements and constructions. Special attention is devoted to studying the influence of composition, thermical proccesing and processing by plastic deformation on the structure and properties of the material. This course enables possible collabortions with institutes, companies and factories that make and construct engineering materials and deal with their application.

learning outcomes

Attending this course student will develop abilities of all encompassing analysis and possibility to predict optimal techno-economical choice of the type of engineering material using scientific methods and modern lab equipment. Due to this course a student will also develop the ability to combine knowledge from different areas of material science, physics, mechanics and strength of materials together with aquired knowledge during this course.

theoretical teaching

Advanced course of Engineering materials. Ferrous and non-ferrous engineering materials and their clasification. Carbon steels, modern steel making processes, ingot casting, casting microstructure, hot and cold working of carbon steels, classification of plane carbon steel, heat treatment, microstructure and properties. Microalloyed steels, precipitation mechanisms, strengthening. Dual-phase steels. Effects of alloying elements on microstructure and properties of alloy steels. Hardenability. Classification of alloy steels. Temper embrittlement in low-alloy steel. Maraging steels. Classification of stainless steels according microstructure, ferritic, martensitic, austenitic, precipitation-hardening stainless steels and duplex stainless steels. Tool steels, classification and properties. High-speed tool steels. Nickel, applications, microstructure, properties. Nickel-based alloys, composition, applications, microstructure, properties.

practical teaching

Aluminium and its alloys. Classification of aluminium alloys, chemical composition, applications, microstructure, properties. Water-hardening tool steels. Hot-work tool steels. Secondary hardening of tool steels. Heat treatment of high-speed tool steels. Powdered alloy, sintering. Superalloys. Casting of superalloys. Problems and tasks: calculation of microstructural phase fractions, engineering designing with alloy steels and aluminium steels properties. Titanium and its alloys, applications, microstructure, properties. Magnesium and zinc alloys. Copper alloys.

prerequisite

Necessary conditions: Engineering materials 1 and 2.
Desired condition: Physics and Strength of material.

learning resources

1. Л. Шиђанин, Машински материјали 2, ФТН-Нови Сад, 1996, КДА
2. Шуман Х., Металографија, ТМФ - Београд, 1981, КДА

number of hours

total number of hours: 45

active teaching (theoretical)

lectures: 12

active teaching (practical)

auditory exercises: 10
laboratory exercises: 0
calculation tasks: 7
seminar works: 8
project design: 0
consultations: 2
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 1
test, with assessment: 2
final exam: 3

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 25
laboratory exercises: 0
calculation tasks: 15
seminar works: 20
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

W.D.Callister: Materials Science and Engineering, An Introduction, 2000, John Wiley, NewYork,
W.Smith: Structure and Properties of Engineering Alloys, 1993, McGrow-Hill,Inc
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/

Finite element method

ID: MSc-0468
teaching professor: Седмак С. Александар
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: engineering materials and welding, tribology, fuels and combustion

goals

learning outcomes

theoretical teaching

practical teaching

prerequisite

learning resources

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 20

active teaching (practical)

auditory exercises: 14
laboratory exercises: 8
calculation tasks: 8
seminar works: 0
project design: 4
consultations: 4
discussion and workshop: 2
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 3
check and assessment of seminar works: 0
check and assessment of projects: 3
colloquium, with assessment: 2
test, with assessment: 2
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 25
laboratory exercises: 20
calculation tasks: 0

seminar works: 0
project design: 15
final exam: 30
requirements to take the exam (number of points): 35

references

Finite element method 2

ID: MSc-0293
teaching professor: Седмак С. Александар
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: engineering materials and welding, tribology, fuels and combustion

goals

Introducing students to the application of finite element method in the analysis of nonlinear problems. Understanding and studying the problems of coupled external loads on welded structures. The development of an independent and practical work using licensed software.

learning outcomes

By attending this course the student will master advanced application of finite element method, especially in the field of welding and welded structures. Theoretical considerations, computational exercises and work with the licensed ABAQUS software, will allow students to synergize the previously acquired knowledge of mathematics, mechanics, structures integrity and mechanical materials, and apply this knowledge in engineering practice.

theoretical teaching

Solving nonlinear problems using the FEM; types of nonlinearities, a review. Introduction to nonlinearity of the materials, the basics of the theory of plasticity. Presentation of the different criteria of plastic flow of materials in the FEM. Connections between strains and stresses in the plastic field - the law of liquid limit and the FEM formulation. The influence of building up the material. The influence of material anisotropy. The problem of heterogeneous materials - application on the welded joints. Problems of the material porosity. Viscoplasticity. Algorithms for solving nonlinear problems; incremental - iterative procedures. Nonlinearity of geometry; analysis of large deformations. Viscoelasticity. Nonlinear boundary conditions: solution for contact problems using formulation of FEM. The problems of dynamic and impact loads. Presentation of the thermal loads, coupled analysis using FEM. Application on the different welding procedures. Techniques of introducing residual stresses. Application of FEM in fracture mechanics and failure. Singular FE. Calculations of J-integrals in the FEM. Crack growth, techniques of node release.

practical teaching

Constitutive expression of non-linear material behavior. Examples of formulations in the FEM. The formation of the real stress – strain curve. Special cases. Development of FEM models of welded joints and elastic-plastic analysis. Examples of solving the problem of anisotropy and porosity of the material; the constitutive expression. Application of various algorithms in solving nonlinear problems; the accuracy and convergence of the solutions. Examples of FEM formulation of nonlinearities of geometry. Development of FEM contact models. FEM formulation of dynamic and impact loadings. Post-processing. Techniques of introducing residual stresses - application on different welding procedures. FEM solutions in assessing fracture integrity of the weld. Examples of calculating J-integral for welded joints.

prerequisite

required: Mathematics 1, 2 and 3, Structural integrity, Finite element method 1; desirable: Numerical methods

learning resources

[1] M. Rakin, A. Sedmak, B. Medjo, M. Dobrojević, Solved examples of using the software package ABAQUS in engineering materials, course materials in preparation
[2] Written lessons from lectures (handouts)
[3] Kojic M., Computational Prrocedures in Inelastic Analysis of Solids and Structures, Kragujevac, 1997.
[4] M. Sekulović, Finite Element Method, Građevinska knjiga, Belgrade, 1988.
[5] ABAQUS User's Manuals, Hibbit, Karlsson & Sorensen, Abaqus Inc., Version 6.5 and upgrades 2005-2007

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 8
laboratory exercises: 8
calculation tasks: 6
seminar works: 0
project design: 4
consultations: 4
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 3
check and assessment of seminar works: 0
check and assessment of projects: 3
colloquium, with assessment: 2
test, with assessment: 2
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 25
laboratory exercises: 20
calculation tasks: 0
seminar works: 0
project design: 15
final exam: 30
requirements to take the exam (number of points): 35

references

The Finite Element Method: Its Basis and Fundamentals, Sixth Edition, O. C. Zienkiewicz, R. L. Taylor and J.Z. Zhu, 2005.
J. N. Reddy, An Introduction to the Finite Element Method (Engineering Series), 2005.
Roger T. Fenner, Finite Element Methods for Engineers, 1997.

Fuel, Lubricants and Industrial Water 2

ID: MSc-0266
teaching professor: Стојиљковић Д. Драгослава
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 2
final exam: oral
parent department: engineering materials and welding, tribology, fuels and combustion

goals

Fuel types. Stoichiometric combustion equations. Combustion temperature. Characterization of solid fuels, technical and fundamental analysis. Solid fuel origins, derivation, applications. Liquid fuels, origins, derivation, applications. Gaseous fuels, origins, derivation, applications. Lubricants, types and main characteristics, applications. Industrial water, types and properties. Essential characteristics of the water for industrial purposes. Problems in the use of natural waters. Water treatment for industrial applications.

learning outcomes

Acquisition of basic knowledge about the concept of fuel types and properties. Mastering the basic techniques of calculation of quantity and composition of the products of combustion and combustion temperature. Acquiring basic knowledge on the characterization of solid fuels, their origins, derivation and application. Basic knowledge of liquid and gaseous fuels, their origins, derivation and application. Basic knowledge about the types of lubricants, properties and application. Basic knowledge about water treatment for industrial applications.

theoretical teaching

The concept of fuel. Fundamentals of combustion, the stoichiometric equations. Calculation of the quantity and composition of combustion products. The combustion temperature, types and methods of calculation. Solid fuels, origins, procedures for derivation and application. Liquid fuels, origins, procedures for derivation and application. Gaseous fuels, origins, procedures for derivation and application. Lubricants: lubricants types, main characteristics relevant for application, the application of lubricants. Industrial water: water types and basic characteristics. Preparation of water for industrial applications, methods.

practical teaching

The conversion from one to another mass of solid fuel. Calculation of heating value of the fuel. Elements of stoichiometry. Combustion temperature . Determination the characteristics of proximate analysis of solid fuels. Determination of heating value of solid and liquid fuels with a bomb calorimeter and the determination of heating value of gaseous and liquid fuels with Junkers calorimeter. Determination of the distillation curve. The significance of the main temperature on distillation curve. Characteristics of fuels at elevated and reduced temperatures. Quality control. Determination of the viscosity of liquid fuels and lubricants (dynamic, kinematic viscosity and relative). Determination of the basic characteristics of grease. Determination of water hardness and acidity.

prerequisite

No special requirements.

learning resources

Milan Radovanovic: Fuels; Milan Radovanovic: Industrial water; Aleksandar Rac: Lubricants; M. Adzic, A. Rac, S. Memetović: Manual for laboratory exercises in Fuels;

number of hours

total number of hours: 30

active teaching (theoretical)

lectures: 15

active teaching (practical)

auditory exercises: 1
laboratory exercises: 9
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 1
test, with assessment: 2
final exam: 2

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 40
laboratory exercises: 10
calculation tasks: 5
seminar works: 0
project design: 0
final exam: 40
requirements to take the exam (number of points): 20

references

Professional practice M-WWS

ID: MSc-0156
teaching professor: Седмак С. Александар
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 1
final exam: project design
parent department: engineering materials and welding, tribology, fuels and combustion

goals

Objectives of this course are that students, after completing theoretical training, are prepared for their maximum involvement in practical training. Objective is that students become competent in the field of welding and gain appropriate academic skills, and also develop specific creative and practical skills that are needed in professional practice.

learning outcomes

By attending this course, provided by the curriculum of the subject, the student will be able to solve particular problems from practice, and to examine the possible consequences that may occur in case of bad solutions. The student will also able to link their knowledge from various fields and apply them in practice.

theoretical teaching

Introducing students to problems in practice.

practical teaching

Professional practice performance in the selected individual firms. Writing a report after practice.

prerequisite

required:Mechanical materials 1 and 2

learning resources

[1] Written lessons from lectures (handouts)
[2] Plavšić N., Šijački-Žeravčić V., Stamenić Z.: Tables of mechanical materials, profiles, sheets and wires, Faculty of Mechanical Engineering, Belgrade, 2004;
[3] Excerpts from the standard

number of hours

total number of hours: 46

active teaching (theoretical)

lectures: 6

active teaching (practical)

auditory exercises: 0
laboratory exercises: 0
calculation tasks: 0

seminar works: 0
project design: 35
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 5
colloquium, with assessment: 0
test, with assessment: 0
final exam: 0

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 100
final exam: 0
requirements to take the exam (number of points): 40

references

Service Properties of Welded Joints

ID: MSc-0719
teaching professor: Бакић М. Гордана
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: engineering materials and welding, tribology, fuels and combustion

goals

The aim of this course is for students to become competent in the area of the analysis the current state of metal during service as well as failure and fracture of welded joints. They should also develop appropriate academic skills and creativity and master practical skills needed for the profession. This course is designed to provide information through theoretical lectures but also through laboratory type (practical) exercises, computational classes and seminar papers students are responsible for writing.

learning outcomes

After fulfilling all the course requirements, a student is capable to: solve concrete problems in the area of detection and recognition of metal damage occurring in service generally, as well as for welded joints; determine potential causes of the damage, and possible opportunities for prevention of further damage. Throughout this course students would also develop the ability to combine knowledge from different areas of material and engineering sciences.

theoretical teaching

Introduction.Fractures. Service properties of welded joints. Mechanical properties. Microstructural properties. Long term exploitation. Stress state. Mechanisms and causes of damage. Types of damage. Dissimilar joints. Corrosion. Damage caused by working conditions and combination of different sources. Damage and defects. Creep. Fatigue. Combination of creep and fatigue. Erosion and abrasion. Analytical diagnostic. Modern maintenance concepts and metal damage monitoring during service.

practical teaching

Fracture. Characterization of welded joints. Mechanical properties. Microstructural properties.Metallography. Types of damage generaly as well as of welded joints. Corrosion. Examples of corrosion damage. Damage caused by environment and combination of different sources. Creep. Creep damage. Microstructural degradation. Deformation and fracture maps. Fatigue. Combination of creep and fatigue. Erosion and abrasion. Criteria for replacements and reparation of welded joints. Technical regulations. New steels for high temperatures. Dissimilar joints. Analytical diagnostic. Reports. Modern maintenance concepts and metal damage monitoring during service.

prerequisite

Necessary conditions for a student to attend this course are: attended course lectures and finished exercises of Engineering materials 2.

learning resources

Structural Engineering HandBook - Fatigue & Fracture, 1999
ASM Metals HandBook Volume Special - Heat-Resistant Material
ASM Metals HandBook Vol 13 - Corrosion, 1987

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 25

active teaching (practical)

auditory exercises: 5
laboratory exercises: 10
calculation tasks: 0
seminar works: 10
project design: 0
consultations: 6
discussion and workshop: 4
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 4
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 6
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 40
laboratory exercises: 0
calculation tasks: 0
seminar works: 15
project design: 0
final exam: 40
requirements to take the exam (number of points): 40

references

ASM Metals HandBook Vol 11 - Failure analysis and preventions, 1986
ASM Metals HandBook Vol 08 - Mechanical Testing and Evaluation, 2000
ASM Metals HandBook Vol 09 - Metallography And Microstructures, 1985
ASM Metals HandBook Vol 10 - Materials Characterization, 1986
ASM Metals HandBook Vol 12 - Fractography, 1987

Specialized joining techniques

ID: MSc-0497
teaching professor: Радаковић Ј. Зоран
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 2
final exam: written+oral
parent department: engineering materials and welding, tribology, fuels and combustion

goals

After the completion of the course 'Specialized Joining Techniques', that includes theoretical and practical lectures (auditory and laboratory exercises, problem solving, seminar work, consultations, etc.), the students are familiar with modern processes and non-conventional material joining techniques, that are constantly being developed and applied in the new modern material joining technologies. The candidates will also master the specific practical skills needed in their profession.

learning outcomes

Upon completion of the designed course programme, the candidate will be familiar with the processes and procedures in the research of specific fields in modern joining technologies. The applied knowledge in the field of Specialized Joining Techniques will enable the candidate to gain the ability to recognize and solve specific problems. Thus, he is prepared to link and apply the acquired knowledge to this and other fields and to track innovations, e.g. in the joining of future materials (for instance, special steels, light metals and alloys, ceramics, composites, polymers, nano-materials).

theoretical teaching

Introduction (procedures, classification; non-conventional procedures; future of joining techniques). Development of modern techniques (safety factors and the environment; skills and training; fields of development; application trends). Soldering and brazing. Welding techniques with applied mechanical energy (friction, friction stir 'FSW', high-frequency, ultrasonic, explosive, magnetic-pulse, cold pressure, diffusion). High energy welding techniques (plasma 'keyhole'; electron beam; laser beam; hybrid). Joining techniques similar to welding (adhesive, joining polymers, composites, and ceramics). Micro-joining and nano-joining (basics; process; materials, application).

practical teaching

Classification of non-conventional joining procedures. Application examples of specialized joining techniques: mechanical pressure (friction, high-frequency, ultrasonic, explosion, magnetic-pulse, cold pressure, diffusion). Application of high energy welding techniques (plasma, electron beam, laser beam). Examples of joining polymers, composites, and ceramics. Class exercises. Laboratory demonstrations of applied techniques.

prerequisite

Completed courses: Engineering Materials 1, Engineering Materials 2, Physics and Measurements.
Course attended: Basics of Welding.

learning resources

1. A. Sedmak, V. Sijacki-Zeravcic, A. Milosavljevic, V. Djordjevic, M. Vukicevic, Engineering Materials - Part Two, (in Serbian), University of Belgrade, Faculty of Mechanical Engineering, 2000.
2. Written lecture and exercise notes (notes/handouts).
3. Instructions for preparing laboratory reports.
4. Internet resources.

number of hours

total number of hours: 30

active teaching (theoretical)

lectures: 13

active teaching (practical)

auditory exercises: 1
laboratory exercises: 1
calculation tasks: 1
seminar works: 5
project design: 0
consultations: 3
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 2
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 2
final exam: 2

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 30
laboratory exercises: 5
calculation tasks: 5
seminar works: 15
project design: 0
final exam: 40
requirements to take the exam (number of points): 40

references

J. Norrish, Advanced Welding Processes, Woodhead Publishing Ltd., 2006.
N. Ahmed, New Developments in Advanced Welding, CRC Press, 2005.
R.S. Mishra, M.W. Mahoney, T.J. Lienert, K.V. Jata (Eds.), Friction Stir Welding and Processing, TMS.
H. Schultz, Electron Beam Welding, Woodhead Publishing Ltd., 1994.
C.T. Dawes, Laser Welding: A Practical Guide, Woodhead Publishing Ltd., 1992.

Structural integrity

ID: MSc-0481
teaching professor: Седмак С. Александар
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: engineering materials and welding, tribology, fuels and combustion

goals

Objectives of this course are that students, after completing theoretical basic training in welding, and with their maximum involvement in practical training (through laboratory exercises, development of computational tasks, writing seminar papers, etc..), become competent in the field of welding and gain appropriate academic skills, and also develop specific creative and practical skills that are needed in professional practice.

learning outcomes

By attending this course, provided by the curriculum of the subject, the student will be able to solve particular problems of structural integrity, and to examine the possible consequences that may occur in case of bad solutions. The student will also able to link their knowledge in this field with other areas and apply them in practice.

theoretical teaching

Theoretical classes: Introduction. Basics of fracture mechanics. Stress and strain in the cracked body. Elastic and elastic-plastic fracture mechanics. Fracture mechanics parameters. Stress intensity factor, crack tip opening, J integral. Application of fracture mechanics in structural integrity. Welds as a place of origin of the cracks. Integrity of welded structures. Estimates in the field of elasticity and elasto-plasticity. The force of crack growth in relation to the material tensile curve.

practical teaching

Practical classes: Determination of fracture mechanics parameters in elastic and elastic-plastic field. Experimental, numerical and analytical methods. Standard procedures for measuring parameters of fracture mechanics, as well as material properties. Chart analysis of fracture and its application to welded seams and construction. Assessment of structural integrity of the given construction example by using all acquired knowledge. Consultation.

prerequisite

required:Materials strength, Mechanics, Fundamentals of structure integrity, Basic of Welding Process and Mechanical materials 1 and 2

learning resources

[1] Written lessons from lectures (handouts)
[2] A. Sedmak, Use of the fracture mechanics on the structure integrity assessment, Faculty of Mechanical Engineering, Belgrade, 2003.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 20

active teaching (practical)

auditory exercises: 9
laboratory exercises: 4
calculation tasks: 7
seminar works: 15
project design: 0
consultations: 2
discussion and workshop: 3
research: 0

knowledge checks

check and assessment of calculation tasks: 1
check and assessment of lab reports: 1
check and assessment of seminar works: 2
check and assessment of projects: 0
colloquium, with assessment: 2
test, with assessment: 4
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 35
laboratory exercises: 10
calculation tasks: 5
seminar works: 15
project design: 0
final exam: 30
requirements to take the exam (number of points): 40

references

Tribological systems

ID: MSc-0537
teaching professor: Венцл А. Александар
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: engineering materials and welding, tribology, fuels and combustion

goals

The student attending this course should:
• Comprehend the issue and the importance of tribological processes in the most important machine elements (slide bearings, roller bearing, gear pairs, guides, seals, etc.);
• Master the calculation methods for tribological elements using the modern lubrication theories;
• Make decisions on selection of the type of lubrication and lubricants for lubrication of the major mechanical elements.

learning outcomes

Based on the mastered knowledge the student is qualified to:
• Exterminates the basic mechanical systems from the tribological point of view by analyzing the structure of tribological systems;
• Propose the solutions for problems originate from the friction and wear process;
• Characterize and calculate the working and tribological characteristics of considered mechanical system.

theoretical teaching

• Definition of the tribological systems; Tribological characteristics of the mechanical systems.
• Bearings – purpose and types; Preliminary selection of bearing types; Reynolds equation.
• Sliding bearings (hydrodynamic, hydrostatic, sintered and self-lubricated); Calculation of: friction, minimum lubricant film thickness, lubricant flow, bearing load and oil or surface temperature; Lubricants selection.
• Roller bearings; Calculation of: friction, minimum lubricant film thickness and oil temperature; Lubricants selection.
• Gear pairs tribology – the influence of lubrication on the reliability and efficiency; Calculation of: friction, minimum lubricant film thickness, oil temperature, etc.; Lubricants selection.
• Cam mechanisms tribology – materials and tribological characteristics.
• Elements with reciprocating linear motion (piston-piston ring-cylinder system, slide ways and guides) – materials and tribological characteristics; Lubricants selection.
• Dynamic seals – type, purpose and materials; Calculation of the tribological characteristics; Lubricants selection.

practical teaching

• Lubricants – role, type, classification and basic properties; Rheology of lubricants; Forms and types of lubrication.
• Examples for sliding bearings (hydrodynamic, hydrostatic, sintered and self-lubricated) tribological characteristics calculation.
• Examples for rolling bearings tribological characteristics calculation.
• Examples for gear pairs and cam mechanisms tribological characteristics calculation.

prerequisite

learning resources

1. --, Handouts for each lecture.
2. A. Rac, Fundamentals of Tribology, Faculty of Mechanical Engineering, Belgrade, 1991, (in Serbian).
3. A. Rac, Lubricants and Machine Lubrications, Faculty of Mechanical Engineering, Belgrade, 2007, (in Serbian).
4. A. Rac, A. Vencl, Sliding Bearing Metallic Materials – Mechanical and Tribological Properties, Faculty of Mechanical Engineering, Belgrade, 2004, (in Serbian).

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 0
laboratory exercises: 0
calculation tasks: 17
seminar works: 0
project design: 0
consultations: 13
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 6
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 4
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 37
laboratory exercises: 0
calculation tasks: 28
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

D. Dowson, G.R. Higginson, Elasto-hydrodynamic lubrication, Pergamon Press, Oxford, 1977.
T.A. Harris, Rolling Bearing Analysis, John Wiley & Sons, New York, 1984.
R.J. Welsh, Plain Bearing Design Handbook, Butterworths, London, 1983.
W.B. Rowe, Hydrostatic and Hybrid Bering Design, Butterworths, London, 1983.
W.A. Gross (Ed.), Fluid film lubrication, John Wiley & Sons, New York, 1980.

Tribology

ID: MSc-0519
teaching professor: Венцл А. Александар
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: engineering materials and welding, tribology, fuels and combustion

goals

The student attending this course should:
• Comprehend the significance of friction, wear and lubrication (tribology keywords) and the problems connected with it, the field of construction and maintenance of mechanical parts and systems;
• Master the fundamental knowledge in these areas of tribology in order to decide the merits of the choice of materials and lubricants for the construction and tribological components;
• Solve problems related to the prevention of wear and competently decide on techniques to improve tribological properties of materials and lubrication technologies.

learning outcomes

Based on the mastered knowledge the student is qualified to:
• Solves the complex tribological problems, with multi-disciplinary approach, in order to ensure the high reliability of machinery and equipment;
• Critically analyze the designed constructions from the standpoint of friction and wear, assessing possible effects on the reliability;
• Use methods for solving problems of mechanical parts and systems lubrication, including the selection of lubricants as a structural element;
• Propose the solutions for reduction of energy and materials dissipation in the machines.

theoretical teaching

• Tribology as a science and technical disciplines and techno-economical importance of tribology.
• Properties of surfaces and the nature of contact of two bodies.
• Friction – the basic causes and principles; Friction of metals and non-metals.
• Wear – mechanisms and types; Wear calculation and measuring methods; Wear prevention.
• Properties of materials for tribological components; Technologies for improving the tribological properties of materials.
• Lubricants – role, type, classification and basic properties; Rheology of lubricants.
• Forms and types of lubrication; Hydrostatic, hydrodynamic, elastohydrodynamic and boundary lubrication.
• Lubrication systems (tasks and roles; procedures and classification; elements definition) and lubricants selection.
• Lubrication services organization and lubricants ecology.

practical teaching

• Tribological losses in the industry and transportation; Tribological improvements studies.
• Characterization of the tribological surfaces; Methods and apparatus for surface roughness measuring; Surface roughness standards; Influence of material processing and machining on the surface roughness; Properties of surface layers.
• Presentation of worn surfaces and machine parts failure due to wear, and wear products (debris).

• Presentation of materials for tribological components and technologies for improving the tribological properties of materials.
• Laboratory practice: "Experimental methods for evaluation of friction and wear"; Measuring of coefficient of friction and wear values for different materials and test conditions.
• Classifications and specifications of lubricants; Methods for lubricants testing.
• Examples and formulas for calculation and design of the tribological elements concerning type of lubrication.
• Laboratory practice: "Experimental methods for evaluation of lubricants basic properties and rheological properties"; Measuring of: flash point and pour point; acid and total base number; foaming tendency; oxidation stability; ash, water and mechanical impurities contents; viscosity and viscosity index.

prerequisite

learning resources

1. --, Handouts for each lecture.
2. A. Rac, Fundamentals of Tribology, Faculty of Mechanical Engineering, Belgrade, 1991, (in Serbian).
3. A. Rac, Lubricants and Machine Lubrications, Faculty of Mechanical Engineering, Belgrade, 2007, (in Serbian).
4. A. Rac, A. Vencl, Sliding Bearing Metallic Materials – Mechanical and Tribological Properties, Faculty of Mechanical Engineering, Belgrade, 2004, (in Serbian).
5. Pin-on disc tribometer; Block-on-ring disk tribometer; Four Ball machine.
6. Various devices for measuring the basic characteristics of liquid lubricants and greases; Viscometer for liquid lubricants; Pressure grease viscometer.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 0
laboratory exercises: 17
calculation tasks: 2
seminar works: 0
project design: 0
consultations: 11
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 2
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 4
test, with assessment: 4
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 55
laboratory exercises: 10
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

B. Ivković, A. Rac, Tribology, Yugoslav Tribology Society, Kragujevac, 1995 (in Serbian).
J. Halling, Principles of Tribology, The MacMillan Press Ltd., London, 1975.
D.F. Moore, Principles and Applications of Tribology, Pergamon Press, Oxford, 1975.
B. Bhushan, Principles and Applications of Tribology, John Wiley & Sons, New York, 1999.
A.R. Lansdown, Lubrication – A Practical Guide to Lubricant Selection, Pergamon Press, Oxford, 1982.

Tribotechnique

ID: MSc-0509
teaching professor: Венцл А. Александар
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: engineering materials and welding, tribology, fuels and combustion

goals

The student attending this course should:
• Master the fundamental knowledge in the areas of lubricants and lubrication;
• Comprehend the significance of failures from the technical and economic aspects;
• Master the skills to evaluate the failure according to the established cause-consequence classifications;
• Comprehend the issue of establishing a diagnostic of machine condition and monitoring programme;
• Increase the availability and productivity of the equipment through a clearly defined technical strategy and to make competent decisions on it.

learning outcomes

Based on the mastered knowledge the student is qualified to:
• Conducts an analysis of the problems connected with maintenance and competently decides on the maintenance program in the tribotechnique area;
• Selects and uses the modern methods for condition-diagnostic and condition-monitoring of the tribological systems;
• Make conclusions, based on monitoring results, about ways how to prevent the failure;
• Carry-out all the maintenance measures in tribotechnique domain and systematically introduce them into the working practice with the aim to reduce the losses due to friction and wear.

theoretical teaching

• Introductory lecture – The objectives and tasks of tribotechnique.
• Lubricants – role, type, classification and basic properties; Rheology of lubricants.
• Forms and types of lubrication; Hydrostatic, hydrodynamic, elastohydrodynamic and boundary lubrication.
• Lubrication systems (tasks and roles; procedures and classification; elements definition) and lubricants selection.
• Lubrication services organization and lubricants ecology.
• The role, objectives and techniques of failure analysis and condition-diagnostics in the construction and maintenance of mechanical systems (casual, permanent, partial, immediate and gradual failure); Failure analysis.
• Tribotechnique activities and sustainable development (maintenance methods, road map to excellence, performance benchmark);
• Lubricants monitoring and the diagnostic methods for tribological components and systems condition.

practical teaching

• Classifications and specifications of lubricants; Methods for lubricants testing.
• Laboratory practice: “Experimental methods for evaluation of lubricants basic properties and rheological properties”; Measuring of: flash point and pour point; acid and total base number;

foaming tendency; oxidation stability; ash, water and mechanical impurities contents; viscosity and viscosity index.
• Examples and formulas for calculation and design of the tribological elements concerning type of lubrication.
• Examples of failure analysis techniques (Fault tree analysis, Ishikawa diagram, Pareto analysis, FMEA, etc.) and their application to the specific tribological components failure case studies;
• Presentation of tribological components damages and failures of, and wear products (debris); Presentation of equipment for tribological components diagnostics.

prerequisite

learning resources

1. --, Handouts for each lecture.
2. A. Rac, Lubricants and Machine Lubrications, Faculty of Mechanical Engineering, Belgrade, 2007, (in Serbian).
3. M. Babić, Lubricating Oil Monitoring, Faculty of Mechanical Engineering, Kragujevac, 2004 (in Serbian).
4. Various devices for measuring the basic characteristics of liquid lubricants and greases; Viscometer for liquid lubricants; Pressure grease viscometer.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 0
laboratory exercises: 9
calculation tasks: 3
seminar works: 7
project design: 0
consultations: 11
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 1
check and assessment of seminar works: 3
check and assessment of projects: 0
colloquium, with assessment: 2
test, with assessment: 4
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 50
laboratory exercises: 5

calculation tasks: 0
seminar works: 10
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

B. Jeremić, Technology of Technical Systems Maintenance, ESKOD, Kragujevac, 1992, (in Serbian).
--, Handbook of Loss Prevention, Springer-Verlag, Berlin, 1978.
R.A. Collacott, Mechanical Fault Diagnosis, Chapman and Hall, London, 1977.
H.E. Boyer (Ed.), Metals Handbook – Failure Analysis and Prevention, American Society for Metals, Metals Park, 1975.
A.R. Lansdown, Lubrication – A Practical Guide to Lubricant Selection, Pergamon Press, Oxford, 1982.

Welding technology procedure

ID: MSc-0469
teaching professor: Седмак С. Александар
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 4
final exam: oral
parent department: engineering materials and welding, tribology, fuels and combustion

goals

Understanding the basic principles of welding technology as a prescribed course of action to be followed when making a weld. Introducing students to techniques of material selection, preparation, preheating, methods and control of welding and subsequent thermal treatment. Understanding and solving exercises in welding technology. Development of an independent paper by creation and presentation of selected seminar papers.

learning outcomes

By attending the course the students are mastering the basic knowledge of welding technology. Theoretical considerations and computational examples enable the student to master all the necessary principles of welding technology needed for the manufacture of welded joints. Introducing students to current modern standards and recommendations in this field.

theoretical teaching

Introduction to basic principles of welding technology. Defining the prior specification of welding technology (PSWT). Qualification of welding technology (QWT). Specification of welding technology (SWT) - analysis of the document defined by JUS EN 288-2 standard, containing information about the manufacturer, the basic material, process and welding position, joint preparation, notch and edges, welding technique, additional material, all welding parameters, preheating temperature and interlayer temperature. Heat treatment after welding. Welding sequence. Qualification of welders - analysis of EN 287-1 standard, which includes the principles on which the qualification testing of professional welders for welding steel by melting is based.

practical teaching

Auditory exercises with examples of welding technology problems. Solving exercises in specification of welding technology - examples include various types and thicknesses of the base metal, welding process and position. Solving exercises in qualification of welding technology - examples include various types and thicknesses of the base metal, welding process and position. The defense and presentation of selected seminar papers.

prerequisite

required: Mechanical Materials 1,2,3; Basic of Welding Process B (M)

learning resources

[1] Written lessons from lectures (handouts)
[2] Plavšić N., Šijački-Žeravčić V., Stamenić Z.: Tables of mechanical materials, profiles, sheets and wires, Faculty of Mechanical Engineering, Belgrade, 2004;
[3] Excerpts from the standard

number of hours

total number of hours: 45

active teaching (theoretical)

lectures: 18

active teaching (practical)

auditory exercises: 5
laboratory exercises: 0
calculation tasks: 6
seminar works: 5
project design: 0
consultations: 2
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 1
check and assessment of lab reports: 0
check and assessment of seminar works: 1
check and assessment of projects: 0
colloquium, with assessment: 2
test, with assessment: 2
final exam: 3

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 25
laboratory exercises: 0
calculation tasks: 20
seminar works: 15
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

fluid mechanics

Biofluid mechanics
Computational Fluid Dynamics (CFD)
Computational Fluid Dynamics (CFD)
Fluid Mechanics M
Gas dynamics
Gas dynamics
Microfluidics and Nanofluidics
Multifase Flow
TRANSPORTATION OF FLUIDS BY PIPELINE

Biofluid mechanics

ID: MSc-0332
teaching professor: Стевановић Д. Невена
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: fluid mechanics

goals

The aim of this subject is getting academic knowledge about fluid dynamical processes in the human body and introducing with scientific methods for predicting, analyzing and studying biological processes caused by biofluid flow.

learning outcomes

Students are qualifying for computing and analyzing by themself biofluid flow processes with contemporary and scientific methods. Also, they obtain the ability to apply these concepts appropriately for modeling biofluid flow in blood vessels, kidneys, lungs and joints.

theoretical teaching

Theoretical lessons contains: fundamental fluid mechanics equations applied on biofluid flow modeling in the human body, basic non-Newtonian fluid models pertaining to human blood flow, blood rheology, cardiovascular system and related diseases, circulatory system, stationary model for blood flow calculation, pulsating blood flow model, define velocity, pressure and flow rate in the blood vessels, the pressure wave propagation caused by heart pulsation, function of the heart valves and their damage influence on the circulatory systems, blood flow and diffusion process in kidneys, diffusion process in haemodialyser, blood and air flows in the lungs, joint friction.

practical teaching

Practical lessons contains: application of the basic fluid mechanics equations, exact solutions for channel and pipe Newtonian fluid flows, creating and solving mathematical models for blood vessels flow, solving models for stationary blood flow in rigid and elastic blood vessels, modeling pulsating fluid flow, calculation of the pressure wave propagation, calculation of the velocity, pressure and flow rate in blood vessels, modeling and calculating diffusion process among blood vessels walls and tissues and application on the haemodialys process and renal flow.

prerequisite

Passed exams in mathematics and fluid mechanic b.

learning resources

Handouts and Mazumdar, N.J., Biofluid Mechanics, World Scientific, 1992.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 9
laboratory exercises: 0
calculation tasks: 6
seminar works: 10
project design: 0
consultations: 5
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 4
check and assessment of projects: 0
colloquium, with assessment: 4
test, with assessment: 2
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 40
laboratory exercises: 0
calculation tasks: 5
seminar works: 20
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

Kleinstreuer, C., Biofluid Dynamics, Principles and Selected Applications, Taylor & Francis, 2006.
Fung, Y.C., Biomechanics Motion, Flow, Stress and Growth, Springer-Verlag, 1990.

Computational Fluid Dynamics (CFD)

ID: MSc-0603
teaching professor: Лечић Р. Милан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: fluid mechanics

goals

The aim of the course is to learn student the following:
1. Basic theoretical knowledge from computational fluid dynamics (CFD)
2. To introduce student to basic methods in engineering calculations in CFD
3. To learn student the basics of programming in CFD
4. To learn student to use open-source CFD software called OpenFOAM

learning outcomes

By attendance of the theoretical and practical parts of teaching process the student should master the basic knowledge in the field of numerical fluid mechanics. This will allow: 1. solving specific engineering problems using methods and procedures of numerical fluid mechanics, 2. development and use of software in the field of numerical fluid mechanics, which allows to perform numerical simulations of flow. Knowledge gained should raise the quality of work within the others similar applicative courses.

theoretical teaching

Flow modeling using computers. Numerical simulation of flow. Types of partial differential equations (PDE). Basics of finite difference method. Approximation of PDEs by finite differences. Methods for solving systems of algebraic equations. Setting the boundary conditions. The accuracy of calculations. Parabolic, elliptic and hyperbolic equations. Finite volume method.
Solving of nonlinear problems. Stability analysis. Generating of numerical grid.
Fundamentals of finite element method.
The basic functions of finite elements. Finite element approximation. Comparison of finite difference and finite element method.
The basic principles of modeling in CFD. Physical description of the discretization of physical domain. Computational domain and determination of mesh size.
Determination of the boundaries. Boundary conditions.
Model testing. Control of the numerical procedure. Monitoring of calculation. Post-processing.

practical teaching

Types of partial differential equations (PDE). Method of characteristics. An example of analytical solutions. Approximation of PDEs by finite differences. Methods for solving systems of algebraic equations. Setting the boundary conditions. Accuracy of calculation. Finite difference methods. Parabolic, hyperbolic and elliptic PDEs. Finite volume method. Solution of nonlinear problems. Stability analysis. Generation of numerical mesh. Fundamentals of finite element method. Finite element approximation. The basic principles of modeling in CFD. Physical description of the discretization of physical domain. Computational domain and determination of mesh size. Determination of the boundaries. Boundary conditions.
Model testing. Control of the numerical procedure. Monitoring of calculation. Post-processing.
OpenFOAM as a tool for CFD. Explanation of CFD procedure in OpenFOAM. Using OpenFOAM.

prerequisite

Passed exams in following courses: Fluid Mechanics B and Fluid Mechanics M.

learning resources

Computational Laboratory SimLab; handouts; OpenFOAM C++ library

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 5
laboratory exercises: 24
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 1
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 8
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 2
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 10
laboratory exercises: 50
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

OpenFOAM user guide
OpenFOAM programmers guide
Handouts

Computational Fluid Dynamics (CFD)

ID: MSc-0134
teaching professor: Павловић Д. Милош
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: fluid mechanics

goals

The aim of the course is to learn student the following:
1. Basic theoretical knowledge from computational fluid dynamics (CFD)
2. To introduce student to basic methods in engineering calculations in CFD
3. To learn student the basics of programming in CFD
4. To learn student to use open-source CFD software called OpenFOAM

learning outcomes

By attendance of the theoretical and practical parts of teaching process the student should master the basic knowledge in the field of numerical fluid mechanics. This will allow: 1. solving specific engineering problems using methods and procedures of numerical fluid mechanics, 2. development and use of software in the field of numerical fluid mechanics, which allows to perform numerical simulations of flow. Knowledge gained should raise the quality of work within the others similar applicative courses.

theoretical teaching

Flow modeling using computers. Numerical simulation of flow. Types of partial differential equations (PDE). Basics of finite difference method. Approximation of PDEs by finite differences. Methods for solving systems of algebraic equations. Setting the boundary conditions. The accuracy of calculations. Parabolic, elliptic and hyperbolic equations. Finite volume method.
Solving of nonlinear problems. Stability analysis. Generating of numerical grid.
Fundamentals of finite element method.
The basic functions of finite elements. Finite element approximation. Comparison of finite difference and finite element method.
The basic principles of modeling in CFD. Physical description of the discretization of physical domain. Computational domain and determination of mesh size.
Determination of the boundaries. Boundary conditions.
Model testing. Control of the numerical procedure. Monitoring of calculation. Post-processing.

practical teaching

Types of partial differential equations (PDE). Method of characteristics. An example of analytical solutions. Approximation of PDEs by finite differences. Methods for solving systems of algebraic equations. Setting the boundary conditions. Accuracy of calculation. Finite difference methods. Parabolic, hyperbolic and elliptic PDEs. Finite volume method. Solution of nonlinear problems. Stability analysis. Generation of numerical mesh. Fundamentals of finite element method. Finite element approximation. The basic principles of modeling in CFD. Physical description of the discretization of physical domain. Computational domain and determination of mesh size. Determination of the boundaries. Boundary conditions.
Model testing. Control of the numerical procedure. Monitoring of calculation. Post-processing.
OpenFOAM as a tool for CFD. Explanation of CFD procedure in OpenFOAM. Using OpenFOAM.

prerequisite

Passed exams in following courses: Fluid Mechanics B and Fluid Mechanics M.

learning resources

Computational Laboratory SimLab; handouts; OpenFOAM C++ library

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 5
laboratory exercises: 24
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 1
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 8
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 2
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 10
laboratory exercises: 50
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

OpenFOAM user guide
OpenFOAM programmers guide
Handouts

Fluid Mechanics M

ID: MSc-0299
teaching professor: Чантрак М. Светислав
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: fluid mechanics

goals

Aims of the course is to introduce students to basic principles and laws in fluid mechanics. Deeper understanding of basic equations of fluid mechanics allows the student to successfully apply them process of finding the solution to specific engineering problems, and also improves his scientific and practical development.

learning outcomes

With successful completion of the study of fluid mechanics student acquires the following knowledge and general skills: analytical thinking, mastering the latest methods and processes of research, application of knowledge in practice, linking basic knowledge in various fields of engineering, creativity, and so on.

theoretical teaching

Physical and mathematical models, principles and phenomena of fluid mechanics. Physical and mathematical foundations of fluid mechanics. Forces, the general state of stress and stress models in fluids. General equations in fluid mechanics. Laws of conservation. Conservation of mass, momentum and energy. Dynamics of inviscid fluid. Two-dimensional potential flow of inviscid fluid. Application of hydrodynamic singularities and theory of analytical functions of complex variable. Dynamics of viscous flow. Navier-Stokes equation. Steady, laminar flow of Newtonian incompressible fluid. Turbulent flows of incompressible fluid. Boundary layer theory and wake. Forces exerted by the fluid on a moving body. Laminar and turbulent jets. One-dimensional model of fluid flow. Basic equations of one-dimensional flow. One-dimensional flow of incompressible fluid. One-dimensional flow of compressible fluid.

practical teaching

Physical explanation of integral and differential relations and vector analysis and field theory. Analysis of conservation equations of mass, momentum and energy. Constitutive relations. Applications of Cauchy-Riemman equations. Basic potential flows. Interaction between hydrodynamic singularities on solid bodies. Zhukovsky function. Dimensional analysis and similarity theory. Darcy formula. Exact solutions of Navier-Stokes equations. Basics of theory of hydrodynamic lubrication. Modeling of turbulent flows. Fully developed turbulent flow in hydraulically smooth and rough pipes. Prandtl equations of boundary layer. Application of momentum equation and methods of calculation. Drag and lift forces. Free non-isothermal jets. Structure of jet and methods of calculation. Application of general Bernoulli equation and momentum equation. Methods of calculation of complex pipe networks. Cavitation in turbomachines and pipes. Calculation of inviscid and viscous compressible flow.

prerequisite

Passed exams in following subjects: Fluid Mechanics B and Thermodynamics B

learning resources

Books of professors from the department, laboratory equipment; printed and hand-written materials (handouts) - authors Cantrak S., Lecic M. and Cocic A

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 28
laboratory exercises: 2
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 2
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 5
test, with assessment: 3
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 45
laboratory exercises: 10
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 40
requirements to take the exam (number of points): 25

references

Fluid Mechanics M (handouts)

Gas dynamics

ID: MSc-0198
teaching professor: Павловић Д. Милош
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: fluid mechanics

goals

The student should:
1. acquire basic theoretical knowledge in the field of gas dynamics;
2. be trained to perform basic engineering calculations of compressible flows;
3. become familiar with the basic procedures for experimental research in gas dynamics.

learning outcomes

Attendance and regular monitoring of the theoretical and practical training the student should master the basic knowledge in the field of gas dynamics. This will enable him, on the one hand, to solve specific engineering problems in the elementary problems of compressible flows, and, on the other hand, help him to better understand other courses based on this scientific area.

theoretical teaching

Basic concepts. Basic equations. Continuity, momentum and energy equation. The concept of entropy. Disturbances of the final intensity. The normal shock wave. Oblique shock waves. Interaction and reflection of shock waves. Prantdl-Mayer expansion.
Flow through the nozzle. Equations for isentropic flow with varying cross-section. Convergent and de Laval nozzle - regimes of flow in the nozzle.
Non-isentropic flow. The influence of friction in the flows of gas in the pipes. Adiabatic and isothermal flow with friction. Flow with heat transfer.Characteristics of sonic flow over a body. Critical Mach number. Boundary layer. Interaction of shock waves and boundary layer. Experimental methods and devices. Methods for flow visualization. Various types of wind tunnels. Basic methods for measuring pressure and temperature. Anemometric methods.

practical teaching

Application of the basic equations of gas flow. Speed of sound. Critical and total values of physical quantities. Assessing the impact of compressibility.
Isentropic gas flow. Calculation of normal shock wave. Conditions for the formation of oblique shock wave. Calculation of oblique shock wave. Calculation of gas flow through a sequence of shock waves. Interaction of shock waves in the flow field. Prandtl-Mayer expansion. Non-linearized airfoil theory. Calculation of the forces exerted by the fluid on airfoil in super-sonic flow.
Calculation of flow through the nozzle. Flow through convergent nozzle. Flow through de Laval nozzle. Supersonic diffuser. Determining the value of reactive force.
Non-isentropic flows. Calculation of adiabatic flows of viscous gas. Calculation of isothermal flow of viscous gas. Calculation of inviscid flows with heat transfer.
Linearized airfoil theory.

prerequisite

Passed exam in course Fluid Mechanics B.

learning resources

1. Handouts; 2. Miloš Pavlović, Zoran Stefanović: Tables for calculation of compressible flows, Faculty of Mechanical Engineering, 2004.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 20
laboratory exercises: 0
calculation tasks: 10
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 4
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 4
test, with assessment: 2
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 50
laboratory exercises: 0
calculation tasks: 10
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

Hadouts

Gas dynamics

ID: MSc-0619
teaching professor: Стевановић Д. Невена
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: fluid mechanics

goals

The student should:
1. acquire basic theoretical knowledge in the field of gas dynamics;
2. be trained to perform basic engineering calculations of compressible flows;
3. become familiar with the basic procedures for experimental research in gas dynamics.

learning outcomes

Attendance and regular monitoring of the theoretical and practical training the student should master the basic knowledge in the field of gas dynamics. This will enable him, on the one hand, to solve specific engineering problems in the elementary problems of compressible flows, and, on the other hand, help him to better understand other courses based on this scientific area.

theoretical teaching

Basic concepts. Basic equations. Continuity, momentum and energy equation. The concept of entropy. Disturbances of the final intensity. The normal shock wave. Oblique shock waves. Interaction and reflection of shock waves. Prantdl-Mayer expansion.
Flow through the nozzle. Equations for isentropic flow with varying cross-section. Convergent and de Laval nozzle - regimes of flow in the nozzle.
Non-isentropic flow. The influence of friction in the flows of gas in the pipes. Adiabatic and isothermal flow with friction. Flow with heat transfer.Characteristics of sonic flow over a body. Critical Mach number. Boundary layer. Interaction of shock waves and boundary layer.
Experimental methods and devices. Methods for flow visualization. Various types of wind tunnels. Basic methods for measuring pressure and temperature. Anemometric methods.

practical teaching

Application of the basic equations of gas flow. Speed of sound. Critical and total values of physical quantities. Assessing the impact of compressibility.
Isentropic gas flow. Calculation of normal shock wave. Conditions for the formation of oblique shock wave. Calculation of oblique shock wave. Calculation of gas flow through a sequence of shock waves. Interaction of shock waves in the flow field. Prandtl-Mayer expansion. Non-linearized airfoil theory. Calculation of the forces exerted by the fluid on airfoil in super-sonic flow.
Calculation of flow through the nozzle. Flow through convergent nozzle. Flow through de Laval nozzle. Supersonic diffuser. Determining the value of reactive force.
Non-isentropic flows. Calculation of adiabatic flows of viscous gas. Calculation of isothermal flow of viscous gas. Calculation of inviscid flows with heat transfer.
Linearized airfoil theory.

prerequisite

Passed exam in course Fluid Mechanics B

learning resources

1.Handouts; 2. Miloš Pavlović, Zoran Stefanović: Tables for calculation of compressible flows, Faculty of Mechanical Engineering, 2004.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 20
laboratory exercises: 0
calculation tasks: 10
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 4
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 4
test, with assessment: 2
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 50
laboratory exercises: 0
calculation tasks: 10
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

Handouts

Microfluidics and Nanofluidics

ID: MSc-0653
teaching professor: Стевановић Д. Невена
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 2
final exam: written+oral
parent department: fluid mechanics

goals

The aim of this subject is getting academic knowledge about fluid dynamical processes in micro and nano flows and introducing with scientific methods for predicting, analyzing and studying gas and liquid flow in structures of micrometer and nanometer characteristic dimensions.

learning outcomes

Students are qualifying for computing and analyzing by themselves pressure, velocity and temperature field in micro and nano structure fluid flow with contemporary and scientific methods. Also, they obtain the ability to recognize specific phenomena which appears in micro and nano fluid flow.

theoretical teaching

Theoretical lessons contains fundamental fluid mechanics equations applied on fluid flow modeling in the micro and nano structures, rarefaction effect, slip and temperature jump boundary conditions, the behavior, manipulation and control of fluids that are confined to structures of nanometer (typically 1-100 nm) characteristic dimensions, adsorption effect and it influence on boundary conditions in micro and nano structures, Lenard-Jones potential, Debye length, electric double layer, electro-kinetic theory, electro-osmotic flows and electro-kinetic flows.

practical teaching

Practical lessons contains: application of the basic fluid mechanics equations, exact solutions for modeling fluid flow in the micro and nano structures which include different effects as rarefaction, slip and temperature jump at the wall, adsorption, Lenard-Jones potential, Debye length, electric double layer and creating and solving mathematical models for electro kinetic and electroosmotic flows.

prerequisite

Third semestar of Master study

learning resources

Handouts and [1] Karniadakis G., Beskok A., Aluru N., Microflows and Nanoflows Fundamental and Simulations, Springer, 2005. [2] Kirby, B., Micro and Nanoscale Transport in Microfluid Devices, Cambridge University Press, 2010. [3] Dongqing L., Encyclopedia of Microfluidics and Nanofluidics, Springer, 2008. [4]Stevanović,N.,Fluid flows in microdevices, Faculty of Mechanical Engineering, Belgrede,2010.

number of hours

total number of hours: 30

active teaching (theoretical)

lectures: 14

active teaching (practical)

auditory exercises: 0
laboratory exercises: 3
calculation tasks: 3
seminar works: 3
project design: 0
consultations: 3
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 1
check and assessment of lab reports: 0
check and assessment of seminar works: 1
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 0
final exam: 2

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 20
laboratory exercises: 0
calculation tasks: 20
seminar works: 10
project design: 0
final exam: 40
requirements to take the exam (number of points): 100

references

Kirby, B., Micro and Nanoscale Transport in Microfluid Devices, Cambridge University Press, 2010.
Dongqing L., Encyclopedia of Microfluidics and Nanofluidics, Springer, 2008.

Multifase Flow

ID: MSc-0457
teaching professor: Црнојевић Ђ. Цветко
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: fluid mechanics

goals

learning outcomes

theoretical teaching

practical teaching

prerequisite

learning resources

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 25
laboratory exercises: 3
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 2
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 2
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 8
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 35
laboratory exercises: 5
calculation tasks: 0

seminar works: 0
project design: 0
final exam: 50
requirements to take the exam (number of points): 20

references

TRANSPORTATION OF FLUIDS BY PIPELINE

ID: MSc-0458
teaching professor: Црнојевић Ђ. Цветко
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: fluid mechanics

goals

learning outcomes

theoretical teaching

practical teaching

prerequisite

learning resources

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 25
laboratory exercises: 0
calculation tasks: 0
seminar works: 5
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 10
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 45
laboratory exercises: 5
calculation tasks: 0

seminar works: 0
project design: 0
final exam: 40
requirements to take the exam (number of points): 20

references

ID: MSc-0685
teaching professor: Црнојевић Ђ. Цветко
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: fluid mechanics

goals

learning outcomes

theoretical teaching

practical teaching

prerequisite

learning resources

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 26
laboratory exercises: 4
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 2
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 5
test, with assessment: 3
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 45
laboratory exercises: 10
calculation tasks: 0
seminar works: 0
project design: 0

final exam: 40
requirements to take the exam (number of points): 20

references

ID: MSc-0562
teaching professor: Црнојевић Ђ. Цветко
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: fluid mechanics

goals

learning outcomes

theoretical teaching

practical teaching

prerequisite

learning resources

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 25
laboratory exercises: 3
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 2
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 2
check and assessment of lab reports: 4
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 5
test, with assessment: 0
final exam: 4

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 35
laboratory exercises: 5
calculation tasks: 0
seminar works: 0
project design: 0

final exam: 50
requirements to take the exam (number of points): 20

references

general machine design

Applied Theory of Plasticity

ID: MSc-0341
teaching professor: Јанковић Д. Миодраг
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: general machine design

goals

Stress-strain state in plastic deformation area and the corresponding dependence. Theoretical and practical foundation for the engineering application on mechanical parts and structures in terms of load capacity, manufacturing technology using the property of plastic deformation. Interpretation of some important destroing and failure phenomena of macro and micro nature in material structure. Methods of strengthening of parts using property of previous plastic deformation.

learning outcomes

Mastering the methods, procedures and processes of mechanical plasticity of materials that are the basis for direct application to specific practical problems in mechanical engineering. Methods for load capacity increasing, material savings and machine parts strengthening using the so-called cold plastic deformation etc., as well as methods of productive process of parts manufacturing by means of plastic deformation.

theoretical teaching

The study of general deformation properties and corresponding mechanical quantities in terms of plasticity, such as: motions, strains, slips, and stresses as the nominal and actual values, the concept of stress tensors, stress and strain tensor deviators and intensity with invariants. Continuity conditions, strain and rate of strain. State equations, Hooke's law, nonlinear elasticity, plasticity state equations, the plasticity surface, Drucker postulate, associated flow law, flow theory - Prandtl-Reuss equations. The theory of small elasto-plastic deformation during increasing and decreasing of load, residual stresses and strains. Application to the components manufacturing with plastic deformation. The appearance of creep, rheological models and its principles.

practical teaching

The stress-strain curve in the elastic-plastic region and some approximate equations. Bauschinger's effect, Gerstner's and Masing's law, elastic limit changes, flows under increasing and decreasing of load by monotone increasing and cyclically varying of load. Simple and complex stress state and flow conditions: Tresca-St. Venant's, Huber-Mises-Hencky's, Ros-Eichinger's, Prager's, Prandtl-Reuss's equations. Estimation of increased load capacity and material savings on the examples of axial tension, bending and torsion - the appearance of plastic joint. Application on the pipe, the cylindrical and spherical vessels with thick walls. Autofretage of pipes and vessels sujected under high pressure. Plane deformation. Examples of plastic deformation processing technology. Examples of creep.

prerequisite

Desirable: Attended and passed the subject: Theory of Elasticity.

learning resources

Laboratory with PC's and equipment.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 12
laboratory exercises: 0
calculation tasks: 8
seminar works: 0
project design: 5
consultations: 5
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 6
test, with assessment: 4
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 55
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 10
final exam: 30
requirements to take the exam (number of points): 35

references

Kachanov, L. M.: Foundation of the theory of plasticity, North-Holland Publishing Company, Amsterdam-London, 1971, in english.
Hoffman, O., Sachs, G.: Introduction to the theory of plasticity for engineers, New York-Toronto-London, McGraw-Hill Company, 1953, in english.

Design and Construction M

ID: MSc-0373
teaching professor: Митровић М. Радивоје
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: general machine design

goals

Acquisition of basic knowledge of designing and constructing machinery elements and structures. Mastering the methods of construction and design process. Developing skills of teamwork and interconnecting knowledge and skills in various fields of Mechanical Engineering. Training for further study.

learning outcomes

Students will gain knowledge, skills and attitudes in the process of constructing in the field of machinery design, as well as experience in selection of the optimal variant design based on techno economic analysis.

theoretical teaching

Stages in the process of designing and constructing. Definition of executors for basic, partial and general functions. The formation of variant solutions and their evaluation - techno economic criteria. Selection of a compromise solution. The variant constructions. The product life cycle. Unification and typization. Measuring chains. The rules and regulations in the design process and constructing. Introduction to basic concepts and regulations related to construction processes in mechanical engineering. The necessity of compliance with regulations. Conformity Assessment. Harmonized standards. CE marking of products. Placing products on the market. Pressure vessels. Thick and thin walls pressure vessels. Operational stresses. Thermal strain. Critical stresses in static conditions. Selection of welded joints in terms of mutual position of parts to be joined. Types of edges and butt welds (shapes and dimensions) and their application domain. The behavior of structures in the area of low cycle fatigue. The behavior of structures in the area of high cycle fatigue. Design and construction of welded structures. Lightweight constructions. Technologibility in the process of constructing.

practical teaching

Variant construction solutions. Construction of typizated parts. Executors of elementary and partial functions. Forming and calculation of measuring chains. Application of rules and regulations in the machinery design process. Essay. Calculation problem training in the field of Pressure vessels. Example of constructing in the area of low fatigue load. Dimension calculation of elementary functions executors. Determination of service life. Calculation of light structures. The essay about dimension calculation of elementary and partial functions executors. Designing from fabrication and assembly point of view.

prerequisite

Passed all fundamental exams on B.Sc studies.

learning resources

Laboratory of general machine design, University of Balgrade, Faulty of Mechanical

Engineering. Handouts, Presentations, Wireless Internet connection and access to the course Web presentation provided with usefull links.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 20

active teaching (practical)

auditory exercises: 30
laboratory exercises: 0
calculation tasks: 0
seminar works: 4
project design: 0
consultations: 6
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 2
check and assessment of projects: 0
colloquium, with assessment: 4
test, with assessment: 4
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 25
laboratory exercises: 0
calculation tasks: 30
seminar works: 10
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

Ognjanović M.: Machine design, Faculty of Mechanical Engineering, Belgrade, 2000.
Karl-Heinz Decker: Machinenelemente: Funktion, Gestaltung und Berechnung, Hanser Verlag, 2000
Orlov P.: Fundamentals of Machine Design, MIR Publishers - Moscow, 1980.
S.Veriga: Machine elements 1, Faculty of Mechanical Engineering, Belgrade
Fundamentals of design - a collection of solved calculated problems, MFB, 1999, ZZD, bibl. FME, in sebian

Development of Machine Systems

ID: MSc-0193
teaching professor: Огњановић Б. Милосав
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: general machine design

goals

The development of creative skills of students in creation of ides for a new, previously unknown, products (mechanical systems). Establishing a correlation of environment, user needs, technology, methods and tools for developing technical solutions, the market conditions and other factors. In addition objective of this course is to master methods for product development to the project as well as methods for defining and processing constraints that lead to high performance products.

learning outcomes

The student has mastered the procedure of abstract thinking and creative adjustment factors that lead to ideas for new, hitherto unknown system. He mastered the procedure and process of defining the limits and conditions to be met by a new product. Trained to use methods and tools for the development of mechanical systems. He mastered the procedures of defining individual characteristics (Design for X - DFX) as well as integrated approaches to product development.

theoretical teaching

Mining and content of product development. Environment and available resources for product development. Incentives for product development: technical and economic. Generating ideas for new products. Management of product development process. The harmony of design and product development. The development of technical systems. Integrated approaches in design. Specific approaches in design. Engineering knowledge (collecting, storing and using of knowledge). Design and reliability (Design for Reliability). Structural parameters and reliability. The probability of working and critical conditions. Design, vibration and noise (Design for Vibration and Noise). The process of generating vibration and noise. Structural measures and solutions to reduce vibration and noise level.

practical teaching

Synchronizing resources, needs and environment (situation). Generating of ideas for new products. Integrated and specific approaches to design. Defining the parameters of the system based on reliability. The probability of service loads and service stresses. Failure probability of machine parts. Hierarchical processing of the overall level of reliability to the level of machine parts. Defining the design parameters of the system based on a limited level of vibration and noise. Correlation of disturbances and the level of vibration and noise. Design solutions for the isolation of vibration and noise.

prerequisite

It is defined by students curriculum.

learning resources

1.Ognjanović M.: Development and Design of machinery (theory, data, made examples) - Faculty of Mechanical Engineering Belgrade 2007., - KPN, MFB bookstore.
2.Electronic materials: hand outs, video clips, product photos, PP presentations - available for the subject teacher
3.Workstations (CAH),-ICT, available in the laboratory 455 (TEMPUS)
4.3D - printer (CAH),-ICT, available in the laboratory, 455 (TEMPUS)
5.Software packages (CATIA, Fast prototyping) (CSP) - ICT, available in the laboratory, 455 (TEMPUS)

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 10
laboratory exercises: 0
calculation tasks: 9
seminar works: 6
project design: 0
consultations: 5
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 2
check and assessment of lab reports: 0
check and assessment of seminar works: 2
check and assessment of projects: 0
colloquium, with assessment: 6
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 30
laboratory exercises: 0
calculation tasks: 20
seminar works: 10
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

Ognjanović M.: Development and Design of machinery (theory, data, made examples) - Faculty of Mechanical Engineering Belgrade 2007
Pahl G., Beitz W.: Engineering Design - A systematic approach, - Springer Verlag
Hubka V., Eder E.: Theory of Technical Systems, - Springer – Verlag
Krause F.L., Franke H.J., Gausemeier J.: Innovations - Potenyiale in der Produktetwicklung, - Carl Hanser Verlag Munchen
Orloff M.A.: Innovative Thinking through TRIZ - A pratical guide, Springer - Verlag

Experiments and simulations

ID: MSc-0716
teaching professor: Маринковић Б. Александар
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: general machine design

goals

Objective of the course is to present and introduce students in crucial need and necessity of experimental investigations such as using simulation methods in design process of mechanical systems development and for design in general. Presenting of methodology, procedures and needed tools in aim to demonstrate how to organize and conduct requested experimental investigations. Intention is also to introduce students in different simulations methods, to explain aims, significance and resources for their application in mechanical system design.

learning outcomes

After following this course, students should acquire knowledge concerning methods, kinds and necessary elements aimed to conduct experimental investigations of machine elements and systems, Students should be able to compose DAQ (data acquisition) for requested investigations subjected to collection and results analysis and presentation. According to available Department laboratory equipment, portable acquisition NI SCC system used to be present in experiments execution, such as basics of LabVIEW software that is common in use in current DAQ systems. Concerning simulation methods, students should have skills in using some of CATIA software modules and to make themselves different simulations of particular mechanical systems.

theoretical teaching

Introduction, about experimental investigations terms and term simulation, reasons for experiment necessity in modern investigations, different types of experiments in general. Experimental investigations of machine elements and systems, basic principles and methods, required elements for experiments investigations. Data Acquisition (DAQ) of experimental investigations, detection signal, transformation, collection and saving of data with further data analysis. Virtual Instrumentation (VI), software tool such as LabVIEW for DAQ and VI. Methods and different groups of simulations, FEM analysis, Digital Mockup as Kinematics simulations. Virtual reality as an advanced way of simulation and important tool in Machine Design and Product Development.

practical teaching

Introduction lesson. Plan and conception of practical examples and exercises. Overview of Laboratory of Department for Machine Design and Design module computer room resources. Different types and required elements for DAQ composition. Introduction in portable NI SCC system for DAQ. Exercises and examples for measurements of temperature, strain and stress of some machine elements and constructions. Basics of LabVIEW software and its application for VI and implementation in DAQ. Presentation and introduction of some special modules in CATIA for different simulations. Exercises and individual work on kinematics simulations.

prerequisite

Required: Attended and passed the Shape Design, Machine Design

Preferred: Attended and passed the Machine Elements 1 and Machine Elements 2

learning resources

book "Shape Modeling" A.Marinković, M.Stanković, Mechanical Engineering Faculty 2011.;
other literature for CATIA V5 software;
hand-outs of lessons;
equipment available in Department Lab 154, for machine elements investigation, portable acquisition NI SCC with LabVIEW software for DAQ experimental investigation,
equipment available in room 455, 3D printer and computers;
CAD working station, CAD software tool CATIA V5

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 10
laboratory exercises: 5
calculation tasks: 5
seminar works: 5
project design: 0
consultations: 5
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 5
check and assessment of projects: 0
colloquium, with assessment: 5
test, with assessment: 5
final exam: 0

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 30
laboratory exercises: 10
calculation tasks: 10
seminar works: 10
project design: 10
final exam: 30
requirements to take the exam (number of points): 35

references

user manual for LabVIEW software NI
"Shape Modeling" A.Marinković, M.Stanković, Mechanical Engineering Faculty University of Belgrade, 2011.
"Experimental investigation of machine constructions 1", D. Josifovic, Mechanical Engineering Faculty University of Kragujevac, 2000.
"CATIA V5 mechanism design and animation", N.Zamani, J.Weaver, Computer Biblioteka Beograd, 2007.
Appropriate literature, available at lecturer office

Failures of technical systems

ID: MSc-0717
teaching professor: Лазовић М. Татјана
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: general machine design

goals

1. Achieving basic knowledge on technical systems and their failures.
2. Understanding dominant failure modes of technical systems and their components in terms of design and operational conditions.
3. Mastering the basics of analytical and empirical procedures for predicting, identifying and preventing technical systems failures, as well as elimination of their causes and consequences).

learning outcomes

At the end of the course student should be able to:
1. define and classify types and modes of technical systems failures or failures of their components
2. to connect causes of technical system/component failure with properties of its design, application and operational conditions
3. to make a proper choice of means and methods of technical system/component failure diagnostics,
4. to propose measures to prevent technical system/component failure,
5. to make appropriate report on analyzed technical system/component failure.

theoretical teaching

Systems. Systems classification. Technical systems (structure, functionality, organization, quality). Structure of life cycle of complex technical system. Technical system development and design. Reliability and safety of technical systems. Technical system operation without failure, service life, maintenance convenience and system stability. Failures of technical systems. Identification of technical systems structure and functions of its elements. Determination of technical system failure causes and effects. Failure modes and their consequences analysis. Risk Assessment. Diagnostic methods and tools (measuring technique) for technical system operation monitoring, failure identification and damage assessment. Characteristics of software support for technical system state monitoring. Damage of the mechanical components of technical systems: journal and rolling bearings, gears, fasteners, axles, shafts and other machine elements and parts. Damages of electronic and software components of technical systems and their consequences. Prodedure of technical system failure analysis. Report on the completed analysis.

practical teaching

On technical systems, analysis of examples about technical systems historical developement. Review and analysis of technical and social requirements in technical systems development. Creating of technical system failure analysis algorithm. Application examples of diagnostic methods and measurement techniques for technical systems failure analysis. Recognizing different types of technical systems failures and identification of their causes (laboratory work). Technical systems failure analysis in cases from actual engineering practice (case studies). Creating of report on carried out technical system failure analysis. Consultation on student project.

prerequisite

No special conditions.

learning resources

Suggested literature includes the necessary material for lectures, exercises and laboratory work. Required additional material (handouts and instructions for laboratory exercises) is given at the web site or as hard copy. Large electronic materials can be available to students in direct contact. Lectures and exercises are carried out using a blackboard and/or video. Laboratory exercises are carried out in the Machine elements laboratory.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 15
laboratory exercises: 2
calculation tasks: 2
seminar works: 9
project design: 0
consultations: 5
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 1
check and assessment of projects: 0
colloquium, with assessment: 6
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 45
laboratory exercises: 0
calculation tasks: 0
seminar works: 20
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

Ognjanović M.: Razvoj i dizajn mašina, Mašinski fakultet Beograd
Ognjanović M.: Mašinski elementi, Mašinski fakultet Beograd
Mitrović R.: Klizni i kotrljajni ležaji, Mašinski fakultet Beograd
Veriga S.: Mašinski elementi (I, II, III), Mašinski fakultet Beograd
Appropriate literature, available at lecturer office

Integrated Technical Systems

ID: MSc-0718
teaching professor: Милош В. Марко
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: general machine design

goals

Acquisition of general and basic knowledge of integrated technical systems, introduction to the structure and terms of technical system as a whole, the basic principles of the system components and the basic approaches to modeling and simulation.
To enable students to understand the complexity of the procedures and systems integration through precise and detailed general methodology.
Developing skills of teamwork and networking skills in various fields.
Training for further study.

learning outcomes

Students will gain knowledge that will enable the engineers work to plan and implement complex processes of modeling, simulation and integration of technical systems.
The knowledge gained will be used in engineering practice to select the basic elements of various technical systems and networking design methods.
Being trained to be responsible teamwork.

theoretical teaching

Integrated technical and technological systems (IT): clarification and definition of the basic concepts, IT systems: fundamentals of design and development of IT systems, structures and basic elements: actuators, sensors, controllers..., modularization and hierarchization. Integration: functional, spatial, methods of designing and connecting various technical units; role of information technology, mechanical components and assemblies, electrical components and circuits, electronic components and sensors; Microcontrollers and Programmable Logic Controllers (PLC), Hydraulic components and assemblies; Pneumatic components and assemblies; Executive elements, Control, modeling and simulation of IT systems: computation and defining the behavior of the system as a whole and the interaction between the individual components, computer models and simulation systems; production processes as IT system: computer integrated manufacturing, product development process, automation; realization of various IT systems.

practical teaching

Exercises include presentation software packages and design packages for simulation and analysis. Also, an example (modeling and simulation) of relatively complex actuator systems (electro-mechanical actuator) as a representative of IT systems will be presented. Upon completion of the calculation and simulation, practical work with actuator: measurement of certain parameters and presentation of contol; Three essays: IT system as a whole; calculation and simulation EMA, HA or PA; modeling IT systems.

prerequisite

learning resources

Moodle (Modular Object-Oriented Dynamic Learning Environment, open-source PHP web application for producing modular internet-based courses that support a modern social constructionist pedagogy)
Lectures, power point presentations, romm equipped with computers & software for design and simulations, laboratory for actuators, handouts.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 10
laboratory exercises: 5
calculation tasks: 0
seminar works: 12
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 13
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 0
laboratory exercises: 15
calculation tasks: 0
seminar works: 45
project design: 0
final exam: 30
requirements to take the exam (number of points): 45

references

M. Milos: Integrated Technical Systems – professor's handouts - Faculty of Mechanical Engineering, 2012.
N. Avgoustinov: Modelling in Mechanical Engineering and Mechatronics – Springer, 2007
R. Dorf, R. Bishop: Modern Control systems – Pearson, 2011.
W. Bolton: Mechatronics-Electronic Control Systems in Mechanical and Electrical Engineering – Pearson, 2012.
B. Wilamowski, D. irwin: Control and Mechatronics – CRC Press, 2012.

Operational Strength

ID: MSc-0305
teaching professor: Јанковић Д. Миодраг
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: general machine design

goals

Registration and statistical analysis of the operational load, the formation of its histograms, the distribution functions, spectra and blocks. Fatigue damage accumulation hypotheses. Calculations of working ability, operational strength, security and reliability and operational life of machine parts and machines exposed to varying operational loads. Experimental methods for fatigue strength estimation and treating of results.

learning outcomes

Methods for registration and statistical analysis of the operational load. The definition of fatigue damage and the process flow of its accumulation using theoretical and experimental methods with appropriate damage hypotheses. Establishment of appropriate criteria for the occurrence of critical fatigue damage phenomena and determination of operational fatigue life. The reduction of results from the variable spectra to equivalent results for the full constant amplitude spectra.

theoretical teaching

The study of statistical processing methods for treating of registered on line operational load and its reduction to step load blocks or spectrum. Various hypotheses on the flow and accumulation of fatigue damage and criteria for the occurrence of critical fatigue phenomena - cracks or failure. Comparison of some hypotheses and their advantages and disadvantages. Palmgren-Miner hypothesis, its assumptions, advantages and disadvantages. Various modifications of this hypothesis. Experimental methods for operational fatigue life and presenting ways of its results. Using such results as a basis for generalized linear hypothesis of fatigue damage accumulation and an more accurate determination of service life for a load spectrum which is different from the experimental one.

practical teaching

Instructions for the statistical analysis of an arbitrary on line operational load flow and the formation of spectra and blocks - the project task. Application of some hypotheses for determination of operational fatigue life and operating strength for a given range of variable load or stress relating to the case of full constant all amplitudes which are equal to the maximum amplitude of the variable spectrum. Examples for numerical determining of fatigue life by applying the Palmgren-Miner hypothesis and its modifications. Testing of some hypotheses using existing experimental results in the literature. Instructions for project work on the fatigue damage accumulation hypotheses at variable amplitudes - fatigue life estimation. Determining of structure mass reduction by apply the analysis of operational fatigue strength.

prerequisite

Desirable: Attended and passed the examen in the subject at the undergraduate level: Fundamentals of machine design - electiv subject.

learning resources

Laboratory with testing machines.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 11
laboratory exercises: 0
calculation tasks: 8
seminar works: 0
project design: 5
consultations: 5
discussion and workshop: 1
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 6
test, with assessment: 4
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 55
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 10
final exam: 30
requirements to take the exam (number of points): 35

references

Gassner, E.: Operational Strength, special edition from Lüger Lexikon der technik, Stuttgart, in german.
Haibach, E.: Operational strength (Betriebsfestigkeit - Verfahren und Daten zur Bauteilberechnung), VDI Verlag, Düsseldorf, 1989, in german.
Buxbaum, O.: Operational strength (Betriebsfestigkeit, sichere und wirtschaftliche Bemessung schwingbruchgefärdeter Bauteile), Stahl und Eisen, 1992, in german.
Collins, J. A.: Failure of material in mechanical design, J. Wiley&Sons, New York, 1981, in english.
Dowling, N. E.: Mechanical behavior of Materials, Pearson, Prentice Hall, Upper Saddle River, 2007, in english.

Profesional training M - DUM

ID: MSc-0157
teaching professor: Огњановић Б. Милосав
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 1
final exam: seminar works
parent department: general machine design

goals

Practical experience and stay of students in environment where they will realize their professional career. Identifying the basic functions of the business system in the area of product development, production and utilization as well as the roles and tasks of mechanical engineering in such a business system.

learning outcomes

Students get practical experience on the organization and functioning of the environment in which they will apply their knowledge in their future professional career. Student identifies models of communication with colleagues and business information flows. The student recognizes the basic processes in the design, manufacture, maintenance, in the context of his future professional competence. Establish the personal contacts that will be able to use at school or entering into future employment.

theoretical teaching

Introduction, objectives, content of activities.

practical teaching

Practical work considers work in organizations that perform various activities in connection with mechanical engineering. Selection of thematic areas and commercial or research organizations carried out in consultation with the concerned teacher. Generally a student can perform the practice in manufacturing organizations, project and consulting organizations, organizations engaged in mechanical equipment maintenance, and public utility companies and some of the laboratories at Faculty of Mechanical Engineering. The practice may also be made abroad. During practice, students must keep a diary in which to enter a description of the tasks performed, the conclusions and observations. Following the practice must make a report to defend the subject teacher. The report is submitted in the form of the paper.

prerequisite

It is no conditions.

learning resources

Organizations that цонтаинс the whole product life cycle, development, manufacture, use.
- Organizations involved in product development.
- Industrial enterprises whose activities are manufacture of products in mechanical engineering.
- Industrial companies whose business is based on the use of mechanical systems
- Companies whose business is distribution and maintenance of machines and components.

number of hours

total number of hours: 46

active teaching (theoretical)

lectures: 0

active teaching (practical)

auditory exercises: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 0
final exam: 46

assessment of knowledge (maximum number of points - 100)

feedback during course study: 70
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

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Reliability of structures

ID: MSc-0486
teaching professor: Ристивојевић Р. Милета
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: general machine design

goals

Acquisition of basic knowledge about the reliability of mechanical components and structures. Mastering the methods of determining the reliability of simple and complex systems. Developing skills of teamwork and networking knowledge and skills in various fields. Training for further study. Consideration of the importance failure from technical and economic point of view, mastering the skills to assess the failure assessment, based on the cause-events established classifications.

learning outcomes

Upon completion of this program is expected that students will be able to:
- recognize the random variables of machine elements and constructions,
- apply analytical and approximate methods for determining the basic reliability indicators,
- draw and use the diagrams of basic indicators of reliability,
- interpret the results of basic reliability indicators obtained from calculations or tests,
- solve engineering problems in the area of reliability.

theoretical teaching

The importance of reliability in the design and construction process of mechanical structures. The definition of reliability. Key indicators of reliability. Estimated and theoretical reliability, confidence level. Reliability of elementary and partial function executor for various failure intensity function: constant function, linear and exponential growing function. Distribution of work and critical stress. Comparative analysis of the construction based on the degree of reliability and safety factor when the values of average operating stress and critical stress change in proportion, and the standard deviation does not change even when the mean values of operational and the critical stress does not change, with a change of standard deviation. The methodology of sizing of elements and joints based on the mechanical design reliability required. Reliability of mechanical structures for different connections (structure) elements: serial, parallel and combined. Statistical analysis of complex tolerance (tolerance of measuring chains). Optimizing the reliability cost. Correlation between reliability and safety factor for different relations of standard deviation and average values of operating and critical stress.

practical teaching

Determination of the basic indicators of the reliability by approximate method. Determining the reliability on the basis of analytic functions of reliability. Distribution of work and critical stress. Dimension calculation of machine elements on the basis of reliability. Reliability structure with serial, parallel and combined connection of elements. Statistical analyses of complex tolerances. Reliability and safety factor correlation.

prerequisite

No

learning resources

General Machine Design Laboratory.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 20

active teaching (practical)

auditory exercises: 18
laboratory exercises: 0
calculation tasks: 8
seminar works: 3
project design: 0
consultations: 8
discussion and workshop: 3
research: 0

knowledge checks

check and assessment of calculation tasks: 2
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 4
test, with assessment: 4
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 25
laboratory exercises: 0
calculation tasks: 30
seminar works: 10
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

Nikola Vujanovic,: The theory of reliability of technical systems, Vojnoizdavacki i novinski centar, Belgrade,1990
Zeljkovic V., Maksimovic S.: Reliability calculation of mechanical elements and structures, Grafokomerc, Belgrade,1998.
Gradimir Ivanović: Reliability of technical systems, Belgrade, 2011
Handouts
Milosav Ognjanović: Develop and machine design , Belgrade, 2000.

Reliability of transmission drives

ID: MSc-0556
teaching professor: Огњановић Б. Милосав
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: general machine design

goals

To develop students ability for recognition mechanical power transformation taking in consideration service resistance probability and failure probability of transmission unit components. Introduce students with calculation methodology of elementary reliability in relation of expected failure of transmission unit component as well as the total reliability of the unit. Recogniзe difference in reliability identification for design of the system and for maintenance. Intake students in design procedure (design parameters selection) based on limited reliability as design constraint. Selected design parameters have to provide maintain of necessary reliability level in the course of transmission unit exploitation.

learning outcomes

Student (Engineer) is qualified by using indicators of service condition probability and failure probability to select traction systems of operating machines. Reliability of train transmission system and components are limitations (constraints) and quality indicators of these systems. Engineer is able using these indicators to estimate, to predict and make decisions in design and exploitation of transmission units.

theoretical teaching

Mechanical power transformation, types of transmission units, types of mechanical transmission units, conceptual and design solution; Service load probability, load spectrums, regimes of service, experimental identification; Endurance of transmission components for experimental conditions (fundamental endurance); Fundamental endurance transformation into service endurance according to load spectrum by application of fatigue damage accumulation; Failure probability in the range of finite fatigue life, infinite fatigue life and in the range of service endurance; Elementary unreliability of transmission unit components (gear pairs, bearings, couplings,....); Reliability of train transmission system and inverse reliability identification of components; Design parameters identification based on axiomatic and robust design.

practical teaching

Numerical examples exercise following lectured content. Pproject task contains design development of transmission unit and reliability identification of transmission unit components and complete train transmission unit.

prerequisite

It is no conditions

learning resources

Lectures, power point presentations, models and simulations of power transmission units service simulation, computers and CATIA software, laboratory for transmission design presentation and laboratory testing presentation, literature, Hand outs etc.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 20
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 10
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 2
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 3
colloquium, with assessment: 5
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 30
laboratory exercises: 0
calculation tasks: 20
seminar works: 0
project design: 10
final exam: 30
requirements to take the exam (number of points): 35

references

Leitch R.D.: Reliability Analysis for Engineers, - Oxford scientific publications
Collins J.A.: Mechanical DEsign of Machine Elements and Machines, - John Wiley and Sons 2003
Roloff/Matek: Machinenelemente, - Vieweg and Sons Braunschweig

Special methods for product development

ID: MSc-0116
teaching professor: Росић Б. Божидар
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: seminar works
parent department: general machine design

goals

The main goal of this course for the student is to give the necessary knowledge of:
• numerical analysis and optimization,
• understanding general principles of design optimization
• formulating the optimization problems and identify critical elements.

learning outcomes

During this course, the student will carry out:
• Overview of design optimization
• Fundamentals of engineering optimization
• Problem formulation
• strategies for optimization

theoretical teaching

1.Introduction to Modeling and Optimum Design Process. Optimum design problem formulation.
A general mathematical model for optimization.
2.Graphical Optimization.Identification of feasible region. Use of MATLAB for graphical optimization.
3. Unconstrained Optimum Design Problems. Optimality conditions for functions of several variables.
4. Constrained optimum design problems. Necessary conditions: equality constraints.
Necessary conditions: inequality constraints - Karush-Kuhn-Tucker (KKT) conditions.
Postoptimality analysis: physical meaning of Lagrange multipliers.
Engineering design examples with MATLAB.
5. Nonlinear Programming. Problem formulation. Graphical solutions. Equality constrained problem. Inequality constrained optimization.
Basic ideas and algorithms for step size determination.
6. Numerical methods - The One-dimensional Problem.
Newton-Raphson method.
Bisection method.
Polynomial Approximation.
Golden section method.
Optimum design examples with MATLAB.
7. Numerical Methods for Unconstrained Optimization.
Numerical Methods - Nongradient methods.
Powell's method.
Numerical Methods-Gradient-Based Methods.
Conjugate Gradient (Fletcher-Reeves) Method.
Davidon-Fletcher- Powel (DFP) method.
8. Numerical Methods for Constrained optimization
Problem definition. Necessary conditions. Method of feasible directions.Gradient projection method.

Exterior penalty function method.
Optimum design examples with MATLAB.
9. Introduction to the Formulation of the Multicriterion Optimization Problem. Decision variables. Constraints. Objective functions.Space of Decision Variables and Space of Objective Functions. Pareto Optimum. Min-Max optimum.
10. Decision Making Problem.
Weighting Objectives Method.
Goal Programming Method.
Interactive Multicriterion optimization method.
Optimization examples.

practical teaching

Consists of the auditory and laboratory exercises.
Projects are main component of this course.

prerequisite

Knowledge of linear algebra and numerical mathematics. Computer programming in MATLAB.
Some knowledge of basic machine elements and mechanics.

learning resources

Computer Usage:
Students extensively use the computer and optimization toolbox using MATLAB program.
Handout.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 8
laboratory exercises: 10
calculation tasks: 0
seminar works: 0
project design: 7
consultations: 5
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 2
colloquium, with assessment: 5
test, with assessment: 3
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 15
laboratory exercises: 0
calculation tasks: 15
seminar works: 0
project design: 30
final exam: 30
requirements to take the exam (number of points): 51

references

Jasbir S. Arora " Introduction to Optimum Design", Elsevier Academic Press
H. Eschenauer, J. Koski, A. Osyczka "Multicriteria Design Optimization", Springer-Verlag
P. Venkataraman " Applied Optimization with Matlab Programming" John Wiley and sons, inc.

Technical regulations and standards

ID: MSc-0141
teaching professor: Митровић М. Радивоје
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: project design
parent department: general machine design

goals

Acquiring basic knowledge in the field of technical regulations and standards. Fully understanding the mutual correlation between international and national technical regulations. Full training for the project documentation making in terms of respect for the essential requirements relevant to technical regulations and standards.

learning outcomes

Students gain knowledge about the content, significance and types of technical regulations and standards, technical legislation of EU directives, conformity assessment procedures, notified bodies, CE marking, market surveillance, machinery safety, risk assessment and national legislation on safety and health at work. The acquisition of appropriate competencies, skills and know-how to use the appropriate technical regulations and standards.

theoretical teaching

Theoretical Studies: The role, importance and types of technical regulations in mechanical engineering. The place and role in the process of technical regulations and machinery design. Standardization. Application scope. Lows about standardization. Low of Accreditation. Low of Metrology. Lows of Technical Directives. Directives and other regulatory legislation documents. EU technical legislation. EU directives. The meaning of new and global approach. Scope of application of the New Approach Directives. Products and goods covered by directives. Compatibility to the Directives. Standard procedure for conformity assessment. Modules. Quality standards application. Notified bodies. Principles of Accreditation. The process of certification. Notified bodies and subcontracting. Coordination and cooperation of notified bodies. CE marking. The principles of the CE markings. Products which is marked with CE. Market surveillance. Principles of market surveillance. Machinery safety. Reliability. Hazard. Risk. Functions of machinery safety. Safety protection. Manual Instruction. Strategy for selection of safety measures. Risk assessment. The evaluation of risk. Law on Safety and Health at work.

practical teaching

Examples of application and use of various types of technical regulations and standards in the construction and design process. Examples of formation and complete technical documentation for obtaining the CE mark for the product. Examples of forming and completing the documentation for the accreditation of laboratories for product testing. Examples and conformity assessment of products. Examples of designing technical solutions for machinery safety and protection. Example of making manual instructions for machinery, equipment or installations. Examples of risk assessment for machinery and mechanical systems. Examples of completing a documentation for the risk assessment. During course, students will visit the following institutions:
- Certified Laboratory for Machinery Elements and System Testing - LIMES, University of Belgrade, Faculty of Mechanical Engineering;
- The Intellectual Property Office of Republic of Serbia;

- Institute for Standardization of Serbia;
- Notified Body of Vinča Institute.

prerequisite

There are no special requirements for attending the course.

learning resources

- Teaching material: Instructions for the application of directives based on new approach and global approach - Danish Technological Institute (translated version) 2006, EU Directive, EU Standards, Standards of Republic of Serbia, the Law on Standardization, the Law on Accreditation Act, the Law on Metrology, Lawc on technical regulations. Required additional materials (handouts, Directives Of Republic of Serbia, etc..) are given at the web site or as a hard copy. Large-scale electronic materials can be made available to students in direct contact.
- Computer equipped classroom;
- Access to Internet;
- Laboratory for General Machine Design, University of Belgrade, Faculty of Mechanical Engineering;
- Certified Laboratory for Machinery Elements and System Testing - LIMES, University of Belgrade, Faculty of Mechanical Engineering;
- Certified Laboratory for Vehicle Testing - CIAH, University of Belgrade, Faculty of Mechanical Engineering;

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 15
laboratory exercises: 0
calculation tasks: 0
seminar works: 2
project design: 0
consultations: 5
discussion and workshop: 8
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 10
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5

test/colloquium: 40
laboratory exercises: 0
calculation tasks: 0
seminar works: 25
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

EU Directives (MD, LVD, EMC, HACCP, ATEX,...)
Actual Directives and regulation books of Reublic of Serbia
Technical regulations and standards, textbook in preparation

hydropower engineering

Application of Turbomachinery
Design computations in turbomachinery
Fans and turbocompressors
Hydraulic Torque Convertors
Hydraulic turbines
Hydraulic turbines
Hydropower measurements
Hydropower measurements
Hydropower plants and equipment
Hydropower plants and equipment
Machine design of pumps, fans and turbocompressors
Mechanical engineering measurements and sensors
Mechanical engineering measurements and sensors
Practical work
Practical work
Pumps
Pumps and fans
Theory of Turbomachinery

Application of Turbomachinery

ID: MSc-0318
teaching professor: Гајић Ђ. Александар
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: hydropower engineering

goals

1. Obtaining the theoretical knowledge on construction and design of turbomachines.
2. Training for the project documentation of a turbomachine (pump or fan). The application of practical knowledge of pumps, turbines and fans in the power systems.
3. Reconciliation of operating characteristics of driving machines and hydraulic couplings and torque convertors in the transport means.

learning outcomes

1. Gaining basic knowledge about the construction of pumps, fans and other turbomachinery.
2. Mastering the methods for design and manufacturing of project and technical documentation specified machines.
3. Studying the ways of choice of hydraulic torque convertors according to the characteristics of driving and driven devices.
4. Obtaining practical experience of exploitation of hydraulic torque convertors, water turbines, pumps and fans.

theoretical teaching

1. Pumps: description, operation and selection. Determination of main dimensions.Characteristics and pump application. Pumping stations. Selection of pumps. Operation and maintenance.
2. Fans. Description, operation and determination of the main measures of radial and cross flow fans. Description and determination of the main measures of axial fans. Compressors. Description and mode of operation. Regulation.
3. Hydraulic turbines. Description of the working conditions of the turbines. Description of the working conditions of double regulated turbines. Reversible pump-turbines. Hydraulic couplings and torque convertors. Hydrostatic convertors. Hydrodynamic torque convertors. Working characteristics of couplings and torque convertors. Principles of calculation. Common operating conditions of couplings or torque convertors and driving device.

practical teaching

Visits waterworks and ventilation systems in order to introduce the operation of turbomachines.
Laboratory exercise: Introduction to ventilation and pumping facilities. Forms and types of impellers flow. Side-effects and damage to turbomachinery. Ways of starting the pump, fan and torque convertor. Project exercise: Calculation of the radial pump or fan with a cylindrical blades flow filled. The calculation and dimensioning of the static parts. Calculation of the main dimensiones. Construction and manufacturing documentation of the impeller. Determination of operation modes in single and parallel operation of pumps or fans in the system. Explanation of the project.

prerequisite

Mandatory exams passed: Fluid Mechanics, Thermodynamics.
Preferred exams passed: Pumps and Fans, Theory of Turbomachinery.

learning resources

Lectures in written and partially in electronic form, written exercises, practical examples of the numerical calculations, computer support.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 15
laboratory exercises: 1
calculation tasks: 3
seminar works: 0
project design: 6
consultations: 2
discussion and workshop: 3
research: 0

knowledge checks

check and assessment of calculation tasks: 4
check and assessment of lab reports: 1
check and assessment of seminar works: 0
check and assessment of projects: 3
colloquium, with assessment: 2
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 10
laboratory exercises: 10
calculation tasks: 10
seminar works: 0
project design: 30
final exam: 30
requirements to take the exam (number of points): 30

references

Krsmanovic Lj., Gajic A., Turbomachines - Pumps, Faculty oh Mechanical Engineering, Belgrade 1996
Krsmanovic Lj., Gajic A., Turbomachines - Fans, Faculty oh Mechanical Engineering, Belgrade 2000
Krsmanovic Lj., Gajic A., Turbomachines - Hydraulic Torque Convertors, Faculty oh Mechanical Engineering, Belgrade 2006

Design computations in turbomachinery

ID: MSc-0444
teaching professor: Недељковић С. Милош
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: hydropower engineering

goals

Mastering knowledge of engineering numerical turbomachinery design. Capacity to work in the design and development offices in the turbomachinery industry. Training for innovation of design methods and acquiring the basis for academic upgrading in computational fluid mechanics application.

learning outcomes

Knowledge of the procedures for turbomachinery design. Knowledge of the consequences of different approaches. Knowledge of hydraulics, numerical and empirical data used in the design. Practical skills acquired by working out the design project.

theoretical teaching

Direct and indirect task in solving flows through the cascades. CAD techniques in the design of turbomachinery. Numerical setting of the meridian section. Numerical grid of constant meridian velocities. Potential grid. Numerical approximate orthogonality between the streamlines and normals. Determination of velocity distribution. Flow calculation using CFD technique. Developing of blades numerically. Numerical adjustment of streamlines in conformal plane. CAD view of a developed blade in the basic plane. Model sections - CAD presentation and control of the spatial form. CAD presentation of the developed spiral casing and control of its spatial shape. Hydro (aero) profiles. Geometric and hydro(aero)dynamics characteristics. Numerical calculation along cylindrical sections. Numerical matching of profiles, controlling of the blade spatial geometry using CAD technique.

practical teaching

Numerical examples of the teaching material on the application of computers in the design calculation of the rotating impeller and stationary elements, in hydraulic and strength calculations using the methods of interpolation, regression, integration and differentiation. Calculations of radial turbomachinery - shaping of the meridional section, the approximate orthogonality between the streamlines and normals; grids of constant meridional velocities and potential grids, CFD calculations of flow, development of radial and axial blades numerically; CAD presentation of the developed blades. Shaping design of spiral casing. Single and double spiral casing. Numerical setting of the spiral casing radial section. Numerical calculation of axial pumps stay vanes.

prerequisite

Passed exams: Fluid Mechanics B, Fluid Mechanics M, Numerical Methods. Preferably knowledge of subject Design of pumps, fans and turbocompressors.

learning resources

Handouts for lectures and exercises. References. Faculty computer classroom. Laboratory for

Hydraulic Machines - spatial layouts of blades of radial and axial machines, and other elements that are calculated.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 0
laboratory exercises: 10
calculation tasks: 5
seminar works: 10
project design: 0
consultations: 5
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 10
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 0
laboratory exercises: 20
calculation tasks: 10
seminar works: 40
project design: 0
final exam: 30
requirements to take the exam (number of points): 21

references

Fans and turbocompressors

ID: MSc-0447
teaching professor: Недељковић С. Милош
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: hydropower engineering

goals

Mastering knowledge of engineering applications of fans and turbocompressors as machines for raising of fluid energy. Capacity to work in practice on energy installations, as well as design of installations that include a fan, blower or turbocompressor as a built-in element with its function.

learning outcomes

Knowledge of types and designs of fans and turbocompressors. Knowledge of the energy parameters and energy balancing. Knowledge of similarity theory to implement the dimensionless parameters - characteristic performance factors. Knowledge of methods of the system working point determination. Knowledge of the energy characteristics of fans/turbocompressors and their significance in establishment of operating regimes of fans/turbocompressors, as well as in thir regulation. Knowledge of the operating characteristics change for fans/turbocompressors working with density other than air.

theoretical teaching

Task and constructions of fans. Examples of application and classification. The calculation of basic dimensions of the fan - the type, impeller diameter, impeller outlet width, spiral casing. Matching and regulation of fans. Testings of fans. Special specifics of fan and fan systems. Axial fans without stay vanes - a characteristic of the fan, its matching. Air curtains, reversible fans, fans for fire conditions, ceiling and roof fans. Noise levels of a fan and fan installation. Task and constructions of turbocompressors, energy balance. The classification of turbochargers. Thermodynamic basis. Efficiency. Uncooled and cooled compressors. The exchange of energy in the axial grid. Multi-stage compressors. Typical performance curves of axial turbochargers and behavior in work (choke and surge limits). Determination of optimal characteristic coefficients of centrifugal compressors. Performance curves of centrifugal compressors and their behavior at work.

practical teaching

Calculation examples of lectured material: Calculation of basic dimensions of the fan. Matching and regulation of fans. Testings of fans. Axial fans without stay vanes - a characteristic of the fan, matching. Noise levels of a fan and fan installation. The energy balance of turbochargers. Thermodynamic basis. Efficiency. Uncooled and cooled compressors. Multi-stage compressors. Typical curves of axial turbochargers and behavior in work. Performance curves of centrifugal compressors and their behavior at work.
Laboratory demonstration exercise: Institute (laboratory) for hydraulic machinery - showing of constructions of fans and turbochargers and description.
Active laboratory exercise: Testing of the fan performance curves.

prerequisite

Passed courses: Fluid Mechanics B, Fluid Mechanics M, Pumps.

learning resources

Textbook: Protic Z, Nedeljkovic M. Pumps and fans. Problems, solutions, theory, 6th ed. Faculty of Mechanical Engineering University of Belgrade, Belgrade 2010.
Handouts for the exercises.
Laboratory for hydraulic machines - equipment, installations, measuring equipment.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 0
laboratory exercises: 5
calculation tasks: 22
seminar works: 0
project design: 0
consultations: 3
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 8
check and assessment of lab reports: 2
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 60
laboratory exercises: 10
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 21

references

Hydraulic Torque Convertors

ID: MSc-0113
teaching professor: Гајић Ђ. Александар
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: hydropower engineering

goals

1. Obtaining of theoretical knowledge of hydraulic torque convertors.
2. Introducing the methods of calculating the dimensioning of the impellers and runners in hydrodynamic torque convertors.
3. Gaining of practical experiences of selection and application of torque convertors to the characteristics of the driving and driven devices.

learning outcomes

1. Gaining basic knowledge about the energy exchange and torque transformation in the hydraulic torque convertors.
2. Mastering the methods of dimensioning of the torque convertors.
3. Mastering the methods for making constructive and manufacturing documentation.
4. Obtainig practical experience for the selection and operation of hydraulic torque convertors.

theoretical teaching

General exploitation. Classification. Transmission scheme and the kinematic calculation of piston pumps. Hydrodinamic torque convertors. Couplings and torque convertors. Working characteristics of couplings and torque convertors. Normal and braking modes. The laws of similarity. Dimensional and dimensionless operating parameters, gear ratio, torques. Characteristics of torques, transparency, flexibility, cost-field zones of exploitation. Fluid flow calculation, specific energy of the pump and turbine. The working process in the torque convertors. Torques, velocity triangles, energy balance. Discharge related to the working regime, the dependence of the torques of the transmission ratio. Calculation of the main dimensiones of the torque convertors. Calculation of the fluid flow through the pump, turbine and guide vanes. Explitation characteristics of couplings. Starting regime. Coupling with the driving device. Common operating conditions of couplings or torque convertors and driving device.Regulation of coupling and torque convertors.

practical teaching

Visit laboratories for testing hydrodynamic torque convertors and / or visits to companies to maintain and service.
Laboratory exercise: Review of construction of hydraulic couplings, impellers and prefabricated removable details on hydraulic torque convertors. Project task: Calculation of the main dimensiones of hydraulic torque convertors according to the law of similarity. Fluid flow calculation in torque convertor. Calculation of velocity triangles in the middle circulation in the normal mode of operation. Profiling the blades of the pump impeller, turbine runner and guide vanes. Preparation scheme of the assembly. Common operating conditions of torque convertors and driving device. Determination of full line characteristics of driving and driven devices with torque convertors.

prerequisite

Mandatory exams passed: Fluid Mechanics.
Preferred exams passed: Fundamentals of Turbomachines,Pumps,Turbines.

learning resources

Lectures in written and partially in electronic form, written exercises, practical examples of the numerical calculations, computer support.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 13
laboratory exercises: 1
calculation tasks: 2
seminar works: 0
project design: 5
consultations: 4
discussion and workshop: 5
research: 0

knowledge checks

check and assessment of calculation tasks: 2
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 6
colloquium, with assessment: 2
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 10
laboratory exercises: 10
calculation tasks: 10
seminar works: 0
project design: 30
final exam: 30
requirements to take the exam (number of points): 30

references

Krsmanovic Lj., Gajic A., Turbomachines - Hydraulic Torque Convertors, Faculty oh Mechanical Engineering, Belgrade 2006.

Hydraulic turbines

ID: MSc-0624
teaching professor: Недељковић С. Милош
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: hydropower engineering

goals

Mastering the theoretical knowledge of fluid flows through the turbine as well as conditions for energy transformation. Definition and determination of the cavitation coefficient in order to protect turbine from cavitation damage. Definition of special factors in order to scale up recalculation from model to prototype characteristics and definition of model universal characteristics and prototype hill charts.

learning outcomes

1. Fundamental knowledge of hydraulic turbines,
2. Essential knowledge for the design of turbines,
3. Mastering the optimum turbine operating parameters,
4. Comprehension of flow processes in hydraulic turbines

theoretical teaching

The theory of hydraulic turbines. Turbines classification; Main turbine parameters; Theoretical basis of flow through the turbine runner; Euler equations for the turbine, Cavitation in turbines; Distribution of pressure in the runner; Cavitation coefficient, Similarity laws of hydraulic turbines, Efficiency scale up recalculation from model to prototype; Turbine discharge regulation, Turbine characteristics: linear and universal; Methods of obtaining universal characteristics, Turbine runaway characteristics; Turbine operation characteristics in power plants abroad. Fundamentals of operation of hydropower plants.

practical teaching

Fundamentals of hydro power plants; Gross and net head, Main turbine parameters; Euler equations for the turbine, Turbine velocity triangles, Similarity laws of hydraulic turbines, Efficiency scale up recalculation from model to prototype, Inflow turbine passages; Stator blades and guide vanes; Turbine discharge regulation; Draft tubes, Universal and operation characteristics; Cam curves; Nomenclature of turbines. Pelton, Francis, Kaplan and Bulb turbines; Choice of hydraulic turbines for the assigned parameters; Cavitation in hydraulic turbines.

prerequisite

Desirable: Theory of turbomachinery, Measurement techniques and sensors

learning resources

[1] Miroslav Benišek "Hydraulic Turbines," Mechanical Engineering in Belgrade, 1998 - KPN, available in the library MFB, in Serbian
[2] Hand-outs - DVL
[3] Guidelines for writing lab reports - DVL
[4] Test rig for determination of model turbine energy and cavitation characteristics - EOP /

LPI
[5] Test rig for Pelton turbines - EOP / LPI

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 10
laboratory exercises: 5
calculation tasks: 11
seminar works: 0
project design: 0
consultations: 2
discussion and workshop: 2
research: 0

knowledge checks

check and assessment of calculation tasks: 1
check and assessment of lab reports: 5
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 4
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 40
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 50
requirements to take the exam (number of points): 30

references

Hydraulic turbines

ID: MSc-0172
teaching professor: Бенишек Х. Мирослав
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: hydropower engineering

goals

Mastering the theoretical knowledge of fluid flows through the turbine as well as conditions for energy transformation. Definition and determination of the cavitation coefficient in order to protect turbine from cavitation damage. Definition of special factors in order to scale up recalculation from model to prototype characteristics and definition of model universal characteristics and prototype hill charts.

learning outcomes

1. Fundamental knowledge of hydraulic turbines,
2. Essential knowledge for the design of turbines,
3. Mastering the optimum turbine operating parameters,
4. Comprehension of flow processes in hydraulic turbines

theoretical teaching

The theory of hydraulic turbines. Turbines classification; Main turbine parameters; Theoretical basis of flow through the turbine runner; Euler equations for the turbine, Cavitation in turbines; Distribution of pressure in the runner; Cavitation coefficient, Similarity laws of hydraulic turbines, Efficiency scale up recalculation from model to prototype; Turbine discharge regulation, Turbine characteristics: linear and universal; Methods of obtaining universal characteristics, Turbine runaway characteristics; Turbine operation characteristics in power plants abroad. Fundamentals of operation of hydropower plants.

practical teaching

Fundamentals of hydro power plants; Gross and net head, Main turbine parameters; Euler equations for the turbine, Turbine velocity triangles, Similarity laws of hydraulic turbines, Efficiency scale up recalculation from model to prototype, Inflow turbine passages; Stator blades and guide vanes; Turbine discharge regulation; Draft tubes, Universal and operation characteristics; Cam curves; Nomenclature of turbines. Pelton, Francis, Kaplan and Bulb turbines; Choice of hydraulic turbines for the assigned parameters; Cavitation in hydraulic turbines,
Laboratory Exercise: Determination of universal characteristics of Pelton turbine

prerequisite

Desirable: Theory of turbomachinery, Measurement techniques and sensors

learning resources

[1] Miroslav Benišek "Hydraulic Turbines," Mechanical Engineering in Belgrade, 1998 - KPN, available in the library MFB, in Serbian
[2] Hand-outs - DVL
[3] Guidelines for writing lab reports - DVL

[4] Test rig for determination of model turbine energy and cavitation characteristics - EOP / LPI
[5] Test rig for Pelton turbines - EOP / LPI

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 10
laboratory exercises: 5
calculation tasks: 11
seminar works: 0
project design: 0
consultations: 2
discussion and workshop: 2
research: 0

knowledge checks

check and assessment of calculation tasks: 1
check and assessment of lab reports: 5
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 4
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 30
laboratory exercises: 10
calculation tasks: 5
seminar works: 0
project design: 0
final exam: 50
requirements to take the exam (number of points): 30

references

Hydropower measurements

ID: MSc-0637
teaching professor: Недељковић С. Милош
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: hydropower engineering

goals

Measurements have a very significant role in engineering practice and research activities. The measurements in hydro energy systems include measuring fluid flow quantities and energy characteristics of hydraulic machinery in order to determine the energy performance of turbines, pumps, fans and other turbomachines. In framework of this subject, the characteristics of valves and methods for determining the cavitation characteristics of hydraulic machines and equipment are studied in detail.

learning outcomes

After successful completion of the study program the student has the necessary knowledge in the field of measurements in hydro energy systems, which is extremely important in his future professional activity. Student can in the best way connect the theoretical and practical knowledge of measuring methods, which introduce him into the world of verification and proof of guaranteed or calculation parameters. In the field of research it offers him the extraordinary opportunity to discover unknown – phenomenon research.

theoretical teaching

The importance of testing in hydro energy systems. Model testing of hydraulic machineries, Standards and recommendations for model tests. Overview of measuring parameters, Pump model tests in the laboratory. Energy and cavitation characteristics determination in pump models - the universal characteristics; Turbine model test in the laboratory, Energy and cavitation characteristics determination of turbine models - the universal characteristics; Hydromechanical equipment test in the laboratory, Energy and cavitation characteristics determination of hydromechanical equipment (valves) , Pumps test in pumping stations, Turbine test in hydropower plants, Fan test in laboratory and in ventilation systems, Compressor test in laboratory and in compressor systems.

practical teaching

Measurements of physical quantities in hydro energy system, Determination of pump energy and cavitation characteristics, Determination of turbine energy and cavitation characteristics, Determination of pump energy and cavitation characteristics at pump station; Determination of the energy performance of turbines in hydro power plant.
Laboratory Exercise: Calibration of measuring equipment, Determination of universal characteristics of the pump and turbine model, Fan test in laboratory and in ventilation systems.

prerequisite

Requirements for examination: Hydraulic turbines, Pumps. Preferred: Measurement techniques and sensors.

learning resources

[1] Hand-outs-DVL
[2] Miroslav Benišek "Hydraulic Turbines," Mechanical Engineering in Belgrade, 1998 .- KPN, available in the library MFB, in Serbian
[3] Test rigs for determination of the energy and cavitation characteristics of turbines, pumps, fans, small hydro power plants, hydromechanical equipment and other turbomachinery - EOP/LPI

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 14
laboratory exercises: 10
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 6
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 6
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 4
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 0
laboratory exercises: 50
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 45
requirements to take the exam (number of points): 30

references

Hydropower measurements

ID: MSc-0132
teaching professor: Бенишек Х. Мирослав
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: hydropower engineering

goals

Measurements have a very significant role in engineering practice and research activities. The measurements in hydro energy systems include measuring fluid flow quantities and energy characteristics of hydraulic machinery in order to determine the energy performance of turbines, pumps, fans and other turbomachines. In framework of this subject, the characteristics of valves and methods for determining the cavitation characteristics of hydraulic machines and equipment are studied in detail.

learning outcomes

After successful completion of the study program the student has the necessary knowledge in the field of measurements in hydro energy systems, which is extremely important in his future professional activity. Student can in the best way connect the theoretical and practical knowledge of measuring methods, which introduce him into the world of verification and proof of guaranteed or calculation parameters. In the field of research it offers him the extraordinary opportunity to discover unknown – phenomenon research.

theoretical teaching

The importance of testing in hydro energy systems. Model testing of hydraulic machineries, Standards and recommendations for model tests. Overview of measuring parameters, Pump model tests in the laboratory. Energy and cavitation characteristics determination in pump models - the universal characteristics; Turbine model test in the laboratory, Energy and cavitation characteristics determination of turbine models - the universal characteristics; Hydromechanical equipment test in the laboratory, Energy and cavitation characteristics determination of hydromechanical equipment (valves) , Pumps test in pumping stations, Turbine test in hydropower plants, Fan test in laboratory and in ventilation systems, Compressor test in laboratory and in compressor systems

practical teaching

Measurements of physical quantities in hydro energy system, Determination of pump energy and cavitation characteristics, Determination of turbine energy and cavitation characteristics, Determination of pump energy and cavitation characteristics at pump station; Determination of the energy performance of turbines in hydro power plant
Laboratory Exercise: Determination of universal characteristics of the pump and turbine model, Hydromechanical equipment test

prerequisite

Requirements for examination: Hydraulic turbines, Pumps. Preferred: Measurement techniques and sensors.

learning resources

[1] Hand-outs-DVL
[2] Miroslav Benišek "Hydraulic Turbines," Mechanical Engineering in Belgrade, 1998 .- KPN, available in the library MFB, in Serbian
[3] Test rigs for determination of the energy and cavitation characteristics of turbines, pumps, fans, small hydro power plants, hydromechanical equipment and other turbomachinery - EOP/LPI

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 14
laboratory exercises: 10
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 6
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 6
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 4
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 30
laboratory exercises: 20
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 40
requirements to take the exam (number of points): 40

references

Hydropower plants and equipment

ID: MSc-0626
teaching professor: Гајић Ђ. Александар
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: hydropower engineering

goals

Connecting theoretical and practical knowledge in fluid mechanics, turbines, pumps and other subjects that can be attended at the Faculty of Engineering as a whole. The development of individual creative abilities in the profession of a designer of hydropower plants. Developing the ability of finding the optimal solution by multi-criteria methods.

learning outcomes

1. General and special abilities to exercise the profession of hydropower plants designer well.
2. Choosing the best solution from a number of alternative ones for the specific task.
3. Confidence in professional activities.

theoretical teaching

Types of hydropower plants; The importance of hydropower plants and accumulations, Plans for building hydropower and reversible plants; Hydro-mechanical equipment in hydropower plants; Design and installation of pipelines; Transient processes in hydropower plants; Pump stations, Pump selection and installation into pump stations; Hydro-mechanical equipment in pump plants; Complex hydro-mechanical systems, Fan and compressor stations; Additional systems in hydro-mechanical plants; Cavitation of valve.

practical teaching

Hydro-mechanical plant; Stages of designing and supporting technical documentation; Providing a basis for design; Hydroelectric power plants in electric power and water management systems; Main power plants parameters; Turbine parameters choice during hydroelectric plants design; Transient processes in power plants; Practical examples in designing hydropower plants, Additional systems in hydropower plants ; Practical examples in designing fan and compressor plants; Excursion to the hydro power plants in national water management and power systems.

prerequisite

Exams passed: Hydraulic turbines, Pumps and Theory of turbomachinery

learning resources

[1] Miroslav Benišek "Hydraulic Turbines," Faculty of Mechanical Engineering in Belgrade, the 1998-KPN, available in the library MFB, in Serbian
[2] Guildline for solving tasks DVL, , in Serbian
[3] Guildline for the design-DVL, , in Serbian
[4] Berlit V. "Hydraulic Turbines” Golovnoe izdatelstvo "Visa skola", Kiev, 1977-KSJ, available in the library MFB, in Russian
[5] N Kovalev, "Guideline for hydro turbines" Mašinostroenie, Leningrad, 1984 XJ, in Russian

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 14
laboratory exercises: 0
calculation tasks: 8
seminar works: 0
project design: 6
consultations: 2
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 6
colloquium, with assessment: 4
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 40
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 25
final exam: 30
requirements to take the exam (number of points): 35

references

Hydropower plants and equipment

ID: MSc-0114
teaching professor: Бенишек Х. Мирослав
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: hydropower engineering

goals

Connecting theoretical and practical knowledge in fluid mechanics, turbines, pumps and other subjects that can be attended at the Faculty of Engineering as a whole. The development of individual creative abilities in the profession of a designer of hydropower plants. Developing the ability of finding the optimal solution by multi-criteria methods.

learning outcomes

1. General and special abilities to exercise the profession of hydropower plants designer well
2. Choosing the best solution from a number of alternative ones for the specific task,
3. Confidence in professional activities

theoretical teaching

Types of hydropower plants; The importance of hydropower plants and accumulations, Plans for building hydropower and reversible plants; Hydro-mechanical equipment in hydropower plants; Design and installation of pipelines; Transient processes in hydropower plants; Pump stations, Pump selection and installation into pump stations; Hydro-mechanical equipment in pump plants; Complex hydro-mechanical systems, Fan and compressor stations; Additional systems in hydro-mechanical plants; Cavitation of valve.

practical teaching

Hydro-mechanical plant; Stages of designing and supporting technical documentation; Providing a basis for design; Hydroelectric power plants in electric power and water management systems; Main power plants parameters; Turbine parameters choice during hydroelectric plants design; Transient processes in power plants; Practical examples in designing hydropower plants, Additional systems in hydropower plants ; Practical examples in designing fan and compressor plants; Excursion to the hydro power plants in national water management and power systems

prerequisite

Exams passed: Hydraulic turbines, Pumps and Theory of turbomachinery

learning resources

[1] Miroslav Benišek "Hydraulic Turbines," Faculty of Mechanical Engineering in Belgrade, the 1998-KPN, available in the library MFB, in Serbian
[2] Guildline for solving tasks DVL, , in Serbian
[3] Guildline for the design-DVL, , in Serbian
[4] Berlit V. "Hydraulic Turbines” Golovnoe izdatelstvo "Visa skola", Kiev, 1977-KSJ, available in the library MFB, in Russian
[5] N Kovalev, "Guideline for hydro turbines" Mašinostroenie, Leningrad, 1984 XJ, in Russian

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 14
laboratory exercises: 0
calculation tasks: 8
seminar works: 0
project design: 6
consultations: 2
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 6
colloquium, with assessment: 4
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 40
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 25
final exam: 30
requirements to take the exam (number of points): 40

references

Machine design of pumps, fans and turbocompressors

ID: MSc-0445
teaching professor: Недељковић С. Милош
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: hydropower engineering

goals

Mastering knowledge of engineering design of pumps, fans and turbochargers. Capacity to work in the design and development offices in the industry of pumps, fans, blowers and turbochargers. Training for innovation of design methods.

learning outcomes

Knowledge of procedures for the design of pumps, fans and turbocompressors. Knowledge of the consequences of different approaches. Knowledge of hydraulics, numerical and empirical data used in the design. Practical skills acquired through the project done.

theoretical teaching

Calculation of radial pump rotating impeller. Meridian section of the impeller and determination of the flow grid. The horizontal projection of the impeller. Point by point design method. The method of conformal mapping. Model sections. Design and calculation of the spiral casing. Design of axial pumps. The choice of optimal characteristic coefficients. Application of the cascade theory for calculation of the axial pump impeller blades and stay vanes. Method of lifting surfaces. The Weing-Eckert method. Design of the inlet confusor (suction bell), diffuser and outlet bend. Determination of hydraulic, volumetric and mechanical losses of the pump. Axial and radial forces: origin, calculation, balancing. Sealing: types and applications. Bearing and construction. Calculation of pump characteristics. Specifics of fans design. Specifics of turbocompressors design. Optimal characteristic coefficients in axial compressors design. Calculation of radial impellers and thier design. The choice of materials and the calculation of strength of certain parts of turbochargers. Basic guidelines for designing of multi-stage turbochargers.

practical teaching

Project examples: Design calculation of radial pump rotating impeller. Shaping of the meridional section and determination of the grid. Formulating the horizontal impeller projection. Point by point method. The method of conformal mapping. Model sections. Design of inlet and outlet stay vanes. Design and calculation of the spiral casing. Application of the cascade theory for calculation of axial pump impeller and stay vanes. Method of lifting surfaces. Method Weing-Eckert. Shaping of impeller and stay vanes. Design of suction bell, diffuser and output bend. Bearing and construction. Specifics of fan design. Special specifics of turbocharger design.

prerequisite

Subjects passed: Pumps, Fluid Mechanics B. Knowledge of basic computer tools.

learning resources

Handouts for lectures and exercises.

Laboratory for hydraulic machines - equipment, installations, measuring equipment.
Faculty computer classroom.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 5
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 22
consultations: 3
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 10
colloquium, with assessment: 0
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 70
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 21

references

Mechanical engineering measurements and sensors

ID: MSc-0360
teaching professor: Бенишек Х. Мирослав
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: hydropower engineering

goals

Research, development and practice in science and engineering cannot be imagined without the experimental methods that are combined in the field of measurement techniques. The aim of this course is to provide basic and specific knowledge in the field of experimental methods necessary for mechanical engineers. The subject involves measuring the nonelectrical quantities in mechanical engineering and their transformation into electrical quantities using sensors. Through specific measurements in the laboratory, students are introduced to the field of practical experimental methods.

learning outcomes

Knowledge that can be applied in practice and research work: Linking theory knowledge with experimental work in mechanical engineering - Fundamental knowledge about measurements of some quantities in mechanical engineering - Practical knowledge of methods of measurements of the different quantities – Knowledge of processing measurement results and determination of the measurement error – Knowledge on possibility of converting non-electrical to electrical quantities and its processing-Knowledge of measurement techniques allows the verification of the theoretical research and modeling process.

theoretical teaching

Theoretical learning is realized through the following core learning areas:
- Error of direct and indirect measurements,
- Theoretical basis of measurement of noncompressible and compressible fluid flow,
- Measurement of pressure and velocity of fluid flow,
- Measuring velocities as vector quantities,
- Temperature measurements,
- Measurement of fluid flow,
- Measurement of humidity. Measuring the frequency of rotation, force, torque and power drive and driven machinery,
- Sensors (types, properties, characteristics, materials). Resistive, capacitive, inductive and generator sensors.

practical teaching

Practical classes:
1) Auditory exercises
- Errors of direct and indirect measurements of measurement quantities,
- Measurement of pressure and velocity of fluid flow,
- Measuring velocities as vector quantities,
- Measuring compressible flow parameters,
- Measurement of the fluid flow,
- Sensors (types, characteristics, dynamic characteristics, materials),
- Resistant, capacitive, inductive and generator sensors.
2) Laboratory exercises

- Determining the pressure distribution around the contour of the cylindrical probe,
- Cylindrical probes calibration.

prerequisite

Desirable: Thermodynamics, Fluid Mechanics, Physics and measurement.

learning resources

[1] M Benišek., M Nedeljkovic., R Kilibarda., Gerasimović D.: "The measurement techniques. Exercises in flow measurements", Mechanical Engineering, Belgrade 2000. - ZZD, available in the library MFB,
[2] Handout from the written lectures - DVL,
[3] Lab reports guidelines - DVL,
[4] The experimental installation for velocity and pressure probes calibration - EOP / LPI, available in the laboratory of HEN,
[5] The experimental installation for calibration of the pressure devices - EOP / LPI, available in the laboratory of HEN,

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 0
laboratory exercises: 6
calculation tasks: 21
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 3
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 5
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 5
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 35
laboratory exercises: 15
calculation tasks: 10
seminar works: 0
project design: 0

final exam: 30
requirements to take the exam (number of points): 30

references

Mechanical engineering measurements and sensors

ID: MSc-0647
teaching professor: Недељковић С. Милош
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: hydropower engineering

goals

Research, development and practice in science and engineering cannot be imagined without the experimental methods that are combined in the field of measurement techniques. The aim of this course is to provide basic and specific knowledge in the field of experimental methods necessary for mechanical engineers. The subject involves measuring the nonelectrical quantities in mechanical engineering and their transformation into electrical quantities using sensors. Through specific measurements in the laboratory, students are introduced to the field of practical experimental methods.

learning outcomes

Knowledge that can be applied in practice and research work: Linking theory knowledge with experimental work in mechanical engineering - Fundamental knowledge about measurements of some quantities in mechanical engineering - Practical knowledge of methods of measurements of the different quantities – Knowledge of processing measurement results and determination of the measurement error – Knowledge on possibility of converting non-electrical to electrical quantities and its processing-Knowledge of measurement techniques allows the verification of the theoretical research and modeling process.

theoretical teaching

Theoretical learning is realized through the following core learning areas:
- Error of direct and indirect measurements,
- Theoretical basis of measurement of noncompressible and compressible fluid flow,
- Measurement of pressure and velocity of fluid flow,
- Measuring velocities as vector quantities,
- Temperature measurements,
- Measurement of fluid flow,
- Measurement of humidity. Measuring the frequency of rotation, force, torque and power drive and driven machinery,
- Sensors (types, properties, characteristics, materials). Resistive, capacitive, inductive and generator sensors.

practical teaching

Practical classes:
1) Auditory exercises
- Errors of direct and indirect measurements of measurement quantities,
- Measurement of pressure and velocity of fluid flow,
- Measuring velocities as vector quantities,
- Measuring compressible flow parameters,
- Measurement of the fluid flow,
- Sensors (types, characteristics, dynamic characteristics, materials),
- Resistant, capacitive, inductive and generator sensors.
2) Laboratory exercises

- Determining the pressure distribution around the contour of the cylindrical probe,
- Cylindrical probes calibration,
- Measurement of temperature sensor parameters.

prerequisite

Desirable: Thermodynamics, Fluid Mechanics, Physics and measurement.

learning resources

[1] M Benišek., M Nedeljkovic., R Kilibarda., Gerasimović D.: "The measurement techniques. Exercises in flow measurements", Mechanical Engineering, Belgrade 2000. - ZZD, available in the library MFB,
[2] Handout from the written lectures - DVL,
[3] Lab reports guidelines - DVL,
[4] The experimental installation for velocity and pressure probes calibration - EOP / LPI, available in the laboratory of HEN,
[5] The experimental installation for calibration of the pressure devices - EOP / LPI, available in the laboratory of HEN,
[6] Laboratories of Institute for physics of Technical faculties.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 0
laboratory exercises: 9
calculation tasks: 21
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 5
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 5
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 35
laboratory exercises: 20
calculation tasks: 5

seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

Practical work

ID: MSc-0627
teaching professor: Гајић Ђ. Александар
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 1
final exam: seminar works
parent department: hydropower engineering

goals

The goal of professional practice is that students in addition to theoretical work within subjects at the faculty get to know and experience the jobs in factories, institutes, laboratories and similar commercial enterprises and thereby gain insight into the activities to be performed. During the practice, students must keep a diary in which they enter a description of the tasks performed, and write down their conclusions and observations. Following the practice, students must write a report that is to be discussed about with the subject teacher.

learning outcomes

Observing the work practices a student acquires special knowledge of specific business enterprises, production facilities, public services and utilities and the like, so their theoretical knowledge can be applied to specific business practice. It is essential to acquire and develop a talent for communication and insight into professional ethics. Also the student has the ability to meet professional experts from whom they will get a good picture of how their knowledge can be usefully applied.

theoretical teaching

The course content is practical work, which consists of spending working time in certain organizations that perform various activities in mechanical engineering. The choice of a theme as well as a business or research organization is made in consultation with the concerned teacher. Students may perform their practice in: design and energy consulting profession organizations, organizations that produce and maintain power equipment, organizations that build and maintain power plants, power plants, waterworks companies and laboratories of the Department of hydraulic machines and power systems.

practical teaching

In the design and consultancy organizations, students are introduced to the process of design and analysis of power plants, acquire practical knowledge of engineering graphics, use of modern computer programs for designing and analyzing equipment and facilities, implementation of measures for rational use of energy and environmental protection and others. In organizations that produce and maintain power equipment they are acquainted with the process of equipment production, technological lines of production, quality control, and others. Within the companies for the construction and maintenance of power plants they acquire knowledge about the organization of construction, layout of equipment and technological systems in plants, and others. In power plants they get to know the appropriate processes, technology systems, fixtures and equipment, methods, process analysis, measurement of process parameters, operating the plant, and others. In the laboratories of the Department of Energy hydropower systems they can become familiar with the available equipment and measuring equipment.

prerequisite

Desirable knowledge in Constructive geometry, Engineering graphics (AutoCAD, Catia, and similar software programs).

learning resources

[1] Instructions for writing reports from professional practice, available in the library of the Faculty of Mechanical Engineering Belgrade (MFB),
[2] Guidelines for handling the equipment and facilities in the laboratories of the Department,
[3] Installation for testing the energy and cavitation features of turbine models, small hydropower plants and hydromechanical equipment, available in the laboratory of HEN,
[4] Installation for flow meter calibration by volume method, available in the laboratory of HEN

number of hours

total number of hours: 46

active teaching (theoretical)

lectures: 0

active teaching (practical)

auditory exercises: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 0
final exam: 46

assessment of knowledge (maximum number of points - 100)

feedback during course study: 70
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

Practical work

ID: MSc-0140
teaching professor: Бенишек Х. Мирослав
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 1
final exam: seminar works
parent department: hydropower engineering

goals

The goal of professional practice is that students in addition to theoretical work within subjects at the faculty get to know and experience the jobs in factories, institutes, laboratories and similar commercial enterprises and thereby gain insight into the activities to be performed. During the practice, students must keep a diary in which they enter a description of the tasks performed, and write down their conclusions and observations. Following the practice, students must write a report that is to be discussed about with the subject teacher.

learning outcomes

Observing the work practices a student acquires special knowledge of specific business enterprises, production facilities, public services and utilities and the like, so their theoretical knowledge can be applied to specific business practice. It is essential to acquire and develop a talent for communication and insight into professional ethics. Also the student has the ability to meet professional experts from whom they will get a good picture of how their knowledge can be usefully applied.

theoretical teaching

The course content is practical work, which consists of spending working time in certain organizations that perform various activities in mechanical engineering. The choice of a theme as well as a business or research organization is made in consultation with the concerned teacher. Students may perform their practice in: design and energy consulting profession organizations, organizations that produce and maintain power equipment, organizations that build and maintain power plants, power plants, waterworks companies and laboratories of the Department of hydraulic machines and power systems.

practical teaching

In the design and consultancy organizations, students are introduced to the process of design and analysis of power plants, acquire practical knowledge of engineering graphics, use of modern computer programs for designing and analyzing equipment and facilities, implementation of measures for rational use of energy and environmental protection and others. In organizations that produce and maintain power equipment they are acquainted with the process of equipment production, technological lines of production, quality control, and others. Within the companies for the construction and maintenance of power plants they acquire knowledge about the organization of construction, layout of equipment and technological systems in plants, and others. In power plants they get to know the appropriate processes, technology systems, fixtures and equipment, methods, process analysis, measurement of process parameters, operating the plant, and others. In the laboratories of the Department of Energy hydropower systems they can become familiar with the available equipment and measuring equipment.

prerequisite

Preferred: The theory of turbomachinery, Pumps, Hydraulic turbines, Fans and turbocompressors.

learning resources

[1] Instructions for writing reports from professional practice, available in the library of the Faculty of Mechanical Engineering Belgrade (MFB),
[2] Guidelines for handling the equipment and facilities in the laboratories of the Department,
[3] Installation for testing the energy and cavitation features of turbine models, small hydropower plants and hydromechanical equipment, available in the laboratory of HEN,
[4] Installation for flow meter calibration by volume method, available in the laboratory of HEN

number of hours

total number of hours: 46

active teaching (theoretical)

lectures: 0

active teaching (practical)

auditory exercises: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 0
final exam: 46

assessment of knowledge (maximum number of points - 100)

feedback during course study: 70
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

Pumps

ID: MSc-0443
teaching professor: Недељковић С. Милош
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: hydropower engineering

goals

Mastering knowledge of engineering applications of pumps as machines for raising of fluid energy. Capacity to work in practice on energy installations, as well as design of installations that include a pump as a built-in element with its function.

learning outcomes

Knowledge of types and designs of pumps. Knowledge of the energy parameters and energy balancing. Knowledge of similarity theory to implement the dimensionless parameters - characteristic performance factors. Knowledge of methods of the system working point determination. Knowledge of the energy characteristics of pumps and their significance in establishment of operating regimes of pumps, as well as in thir regulation. Knowledge of the pump cavitation characteristics.

theoretical teaching

Description of pumps. Energy balance. Definition of the internal work, impeller work and useful work. Flow work per unit - the head. Determination of the head by definition and along the pipeline route. Euler equation for turbomachinery. The impact of the impeller outlet angle on the impeller head and on the reaction factor. Impeller head reduction - the impact of a finite number of blades. Powers and efficiencies of pumps. The laws of similarity. Characteristic ceofficients of pumps. Classification of pumps by types. Cavitation. Cavitation reserve. The cavitation coefficient. Suction head determination. The influence of fluid properties on the characteristics of pumps - the impact of fluid viscosity on pump performance. The calculation of basic dimensions of pumps. Matching of pump performance curves with installation characteristics and regulation of pumps. Selection of pumps. Testings of pumps. Application of pumps in various plants. Piston pumps - description, classification, and the working principle. Nonuniformity of flow rate. Indicator diagram. Determination of power and suction height. Description of the rotating-piston pumps.

practical teaching

Calculation examples of the lectured material: The energy balance. Determination of head by definition and along the pipeline route. Euler equations for turbomachines. Impeller head reduction. Powers and efficiencies of pumps. The laws of similarity. Characteristic coefficients of pumps. Cavitation reserve. Suction head determination. Pumps matching and regulation. Pumps in various plants.
Demonstrative laboratory exercises: Institute (laboratory) for hydraulic machinery - showing PF constructions and description of the role of individual parts. Pump installations and description of their work.

prerequisite

The Fluid Mechanics B exam obligatory passed. Desirable that the student has passed the examination of the subject Introduction to Energy Engineering.

learning resources

Textbook: Protic Z, Nedeljkovic M. Pumps and fans. Problems, solutions, theory, 6th ed. Faculty of Mechanical Engineering University of Belgrade, Belgrade 2010.
Handouts for the exercises.
Laboratory for hydraulic machines - equipment, installations, measuring equipment.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 26
laboratory exercises: 2
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 2
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 10
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 70
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 21

references

Pumps and fans

ID: MSc-0446
teaching professor: Недељковић С. Милош
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: hydropower engineering

goals

Mastering knowledge of engineering applications of pumps and fans as machines for raising of fluid energy. Capacity to work in practice on energy installations, as well as design of installations that include a pump or blower as a built-in element with its function.

learning outcomes

Knowledge of types and designs of pumps and fans. Knowledge of the energy parameters and energy balancing. Knowledge of similarity theory to implement the dimensionless parameters - characteristic performance factors. Knowledge of methods of the system working point determination. Knowledge of the energy characteristics of pumps/fans and their significance in establishment of operating regimes of pumps/fans, as well as in thir regulation. Knowledge of the pump cavitation characteristics and operating characteristics change for fans working with density other than air.

theoretical teaching

Description of pumps and fans (PF). Energy balance. Definition of the internal work, impeller work and useful work. Flow work per unit - the head. Determination of the head by definition and along the pipeline route. Euler equation for turbomachinery. The impact of the impeller outlet angle on the impeller head and on the reaction factor. Impeller head reduction - the impact of a finite number of blades. Powers and efficiencies of PF. The laws of similarity. Characteristic ceofficients of PF. Classification of PF by types. Cavitation. Cavitation reserve. The cavitation coefficient. Suction head determination. The influence of fluid properties on the characteristics of PF - the impact of fluid viscosity on pump performance, and the influence of gas density on the characteristics of the fan. The calculation of basic dimensions of PF. Matching of PF performance curves with installation characteristics and regulation of PF. Selection of PF. Testings of PF. Application of PF in various plants. Piston pumps - description, classification, and the working principle. Nonuniformity of flow rate. Indicator diagram. Determination of power and suction height. Description of the rotating-piston pumps.

practical teaching

Calculation examples of the lectured material: The energy balance. Determination of head by definition and along the pipeline route. Euler equations for turbomachines. Impeller head reduction. Powers and efficiencies of PF. The laws of similarity. Characteristic coefficients of PV. Cavitation reserve. Suction head determination. PF matching and regulation. PF in various plants. Piston pumps - principles of work. Demonstrative laboratory exercises: Institute (laboratory) for hydraulic machinery - showing PF constructions and description of the role of individual parts. PF installations and description of their work.

prerequisite

The Fluid Mechanics B exam obligatory passed. Desirable that the student has passed the examination of the subject Introduction to Energy Engineering.

learning resources

Textbook: Protic Z, Nedeljkovic M. Pumps and fans. Problems, solutions, theory, 6th ed. Faculty of Mechanical Engineering University of Belgrade, Belgrade 2010.
Handouts for the exercises.
Laboratory for hydraulic machines - equipment, installations, measuring equipment.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 26
laboratory exercises: 2
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 2
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 10
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 70
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 21

references

Theory of Turbomachinery

ID: MSc-0281
teaching professor: Гајић Ђ. Александар
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: hydropower engineering

goals

1.Introduction of theoretical knowledge of fluid flow in turbomachinery.
2.Studying of energy and exploitation characteristics of turbomachinery in dimensional and non-dimensional forms and their application in mechanical systems.
3. Obtaining of practical skills application of pumps, turbines and fans in power systems.

learning outcomes

1. Gaining basic knowledge about the exchange of energy in turbomachinery.
2. Reaching the methods of fluid flow computation in turbomachinery.
3. Understanding the control and the energy efficiency of turbomachinery. Measures of preventing or reducing the undesirable effects of cavitation in turbomachinery.
4. Obtaining practical experience of exploitation of turbines, pumps and fans.

theoretical teaching

1. The principles of energy exchange in turbomachinery, the theoretical basis of thermodynamic. Energy balance in the turbomachines and impellers.
2. Characteristics of different type of turbomachinery: pumps, fans, compressors, hydraulic turbines and hydraukic torque convertors. Specific hydraulic energy. Laws of similarity and dimensionalless characteristics.
3. Viscous and non viscous fluid-flow through the turbine runners and pump impellers. Absolute and relative fluid flow in turbomachinery impellers and runners. Phenomena in fluid flow in turbomachinery.
4. Energy and cavitation characteristics of pumps and water turbines and compliance with the systems characteristics.
5. Control of turbomachinery.

practical teaching

Visits to the waterworks and ventilation systems in order to introduce the work of turbomachines. Laboratory exercises: turbomachinery in hydraulic and ventilation systems.Different types of runners and impellers. Exploatation of turbomachines.Operating characteristics of pumps and fans. Dimensional and dimensionless charts. Calculation of specific hydraulic energy of pumps, fans and compressors. Specific hydraulic energy of the runner and impeller and turbomachinery efficiency. Verification of cavitation characteristics of pumps and hydraulic systems.The laws of similarity and dimensionless characteristics. Cavitation characteristics of the pumps and the systems. Control of turbomachinery.

prerequisite

Compulsory examinations passed: Fluid Mechanics, Thermodynamics.
Preferred exams passed: Basis of Turbomachinery, Pumps and Fans.

learning resources

Lectures in written and partially in electronic form, written exercises, practical examples of the numerical calculations, computer support.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 15
laboratory exercises: 3
calculation tasks: 3
seminar works: 0
project design: 0
consultations: 4
discussion and workshop: 5
research: 0

knowledge checks

check and assessment of calculation tasks: 4
check and assessment of lab reports: 2
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 4
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 30
laboratory exercises: 20
calculation tasks: 10
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

Krsmanovic Lj., Gajic A., Turbomachinery - Theoretical Basis, Faculty of Mechanical Engineering, Belgrade 2005.
Gajic A., Pejovic S., Turbomachinery - Illustrative and Test Exams, Faculty of Mechanical Engineering, Belgrade 1993.

industrial engineering

Database Systems

ID: MSc-0521
teaching professor: Мисита Ж. Мирјана
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: industrial engineering

goals

The aim of this course is to prepare students for working with complex databases in production companies. The aim of this course is usage of industrial engineering methods and techniques in the creation of different database queries and scripts. Also, the aim of course is usage of complex database for improvement of decision-making process and management of business-production system.

learning outcomes

The outcome of this course is to use complex databases in practical work, for solving some problems of industrial engineering like:
• Use of complex databases in order to rationalize resources in business- production system,
• Improving the quality of decision-making process in solving problems of industrial engineering.

theoretical teaching

1. Basic concepts of - database, databases, knowledge bases. Types of databases - hierarchical, network, relational model, object-oriented data model. Systems for database management. Standard SQL language. SQL data types. Queries. Examples of SQL functions.
2. Methods and techniques of industrial engineering - scripts in the SQL language. Defining the scripts for: rationalization of operating costs (QC diagram, critical point, ABC method) for calculating the machine capacity efficiency degree, and other scripts that involve application of industrial engineering methods and techniques in the analysis of operations of the relevant business-production system.

practical teaching

Design of database, tables and indexes. Using of SQL query. Operators and functions in the SQL language. For the relevant example in practice, by using SQL language, defining scripts for: rationalization of operating costs (QC diagram, critical point, ABC method) for calculating the degree of efficiency of machine capacity, and other scripts that involve application of industrial engineering methods and techniques in the analysis of operations of the relevant business-production system.

prerequisite

Enrolled 3rd semestar of Master study.

learning resources

1. Handouts,
2. Computer classroom,
3. Software tool: MySQL,
4. Resuources form http://www.mysqul.com/

5. Database from concrete enterprise, in order to get practice on real example.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 20

active teaching (practical)

auditory exercises: 0
laboratory exercises: 40
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 5
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 5
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 30
laboratory exercises: 30
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 10

references

Johnson, J., Database - Models, Languages, Design, Oxford University Press, Oxford, 1997.
Beaulieu, A., Learning SQL, O'Relly Media, 2009.
Geherke, J., Database Management System, McGraw-Hill, New-York. 2003.

Design of logistic and warehouse systems

ID: MSc-0420
teaching professor: Петровић Б. Душан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: industrial engineering

goals

Achieving competency and academic skills in the process of industrial system design. Special emphasis is focused on development of creative skills and overwhelm with specific practical skills needed for professional practice using operational research methods, procedures of analysis and synthesis for obtaining final goal which is optimal practical solution.

learning outcomes

Curriculum overcome enables converge of the following skills: analysis, synthesis and prediction of solutions in design process based on knowledge applying in practice using professional ethics as well as development of crucial and self-critical thinking and approach.

theoretical teaching

Logistic system in industrial environment (connection of production system with transport system, management of demand and purchase and warehouse system). Design system documentation (fusibility study, conceptual solution, conceptual design, tender documentation, main technological-mechanical project, other main projects, final contractor project and project of carried out state). Previous analysis needed for system design (general conditions for urban planning, logistics and transport connections, energetic potential). Design process procedure. Project realisation and generation of results.

practical teaching

Audit lessons (Introduction in design process for defined logistic-distribution system. Activity analysis for forming conceptual solution and conceptual design, activities connected with choosing of technological and other equipment, activities on forming main technological-mechanical project and final contractor project).
Project workmanship (Workmanship of the logistic-distribution system project. Defining of necessary parameters and surroundings for the given system design. Defining of needed system capacities. Forming of assignments for the other projects. Realisation of main technological-mechanical project).

prerequisite

There is no special conditions needed for course attending

learning resources

1. Bugaric, U., Petrovic, D.: Lecture handouts, Faculty of Mechanical engineering Belgrade, Belgrade, 2008-2011.
2. Bugaric, U., Petrovic, D.: Servicing system modelling, Faculty of Mechanical engineering Belgrade, Belgrade, 2011.
3. Bugaric, U.: Methodology for analysis of single position machines work, Foundation Andrejevic, Belgrade, 2003.

4. Zrnić, Đ., Petrović, D.: Factory design – assortment of solved examples, Faculty of Mechanical engineering Belgrade, Belgrade, 1990.
5. Zrnić, Đ., Petrović, D.: Stochastic process in transport, Faculty of Mechanical engineering Belgrade, Belgrade, 1994.
6. Practical instruction in industrial environment.
7. Personal computers.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 4
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 26
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 4
colloquium, with assessment: 6
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 20
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 40
final exam: 30
requirements to take the exam (number of points): 30

references

Asimow, M.: Introduction to Design, Prentice-Hall, Englewood Cliffs, New Jersey, 1962.
Hall, A. D.: A methodology for systems engineering, Van Nostrand, Princeton, New Jersey, 1962.
Kleinrock, L.: Queueing Systems, Volume I: Theory, John Wiley & Sons, New York, 1975.
Hillier, F. S., Lieberman, G. J.: Introduction to operations research (seventh edition), McGraw-Hill, New York, 2000.
Muther, R.: Systematic Layout Planning, Cahners Publishing Company Inc., Boston, 1973.

Engineering Economy

ID: MSc-0418
teaching professor: Милановић Љ. Драган
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: industrial engineering

goals

The objectives of this course are to guide students in engineering and the respective economic and financial processes and to inform them of the relations, connections and rules by which these processes take place in the generation and selection of optimal variant of projects for the overall success in achieving development goals of enterprise

learning outcomes

Mastering this program, student obtains the following general skills: analysis and synthesis and forecasting solutions and consequences; mastery of methods, procedures and processes of research; application of knowledge in practice.
He also obtains the following subject-specific skills: solving practical problems using scientific methods and procedures, linking basic knowledge in various fields and their applications

theoretical teaching

Introduction to analysis and evaluation of the effectiveness of projects; contents of the investment study; analysis of the solvency of company- investor; market analysis; analysis of technical and technological aspects of investment; analysis of organizational and managerial aspects of investment; ecological analysis and economic-financial analysis.
Time value of money; methods of calculating interest and the calculation of interest formula.
Methods of project evaluation: method of net present value, method of annual equivalent worth, method of IRR, MAPI method, benefit-cost analysis.
Depreciation - types of depreciation, methods of calculating depreciation.
Cost Analysis - classification of costs from an engineering standpoint.
A concrete analysis of projects: analysis of operational, investment and financial activities of the project; the influence of inflation and risk on project analysis.

practical teaching

1. auditory exercise: Recovering material from the first hours of lectures with detailed analysis of contents of the investment study . 2. auditory exercise: technical, technological and ecological aspects of the project and 3. auditory exercise: economic-financial analysis of the investment study.
1. computational practice: tasks of the time value of money and the NPV method.
2. computational practice: tasks of the annual equivalent worth method. 3. computational practice: tasks of the method of IRR. 4. computational practice: tasks of the MAPI method and depreciation. 5. computational practice: tasks of cost analysis. 6. computational practice: tasks of analysis of operational, investment and financial activities of the project and analysis of projects under the influence of inflation. 7. computational practice: tasks of analysis of projects under the influence of risk.

prerequisite

The student must be enrolled in the first year of academic studies (the second semester).

learning resources

1.Handouts
2.Dubonjic R, Milanovic Lj D: Engineering Economy, Publishing Centre of Industrial Management Plus, Krusevac, 2005. (in Serbian)
3.Milanovic Lj D and others: Making of investment study, Belgrade, 1998. (in Serbian)

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 8
laboratory exercises: 0
calculation tasks: 16
seminar works: 0
project design: 0
consultations: 6
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 4
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 6
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 35
laboratory exercises: 0
calculation tasks: 30
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

Park, Ch: Contemporary Engineering Economics, Addison-Wesley Publishing Company, 1993.
Young, D.: Modern engineering economy, John Wiley & Sons, 1993.
Shtub A, Bard J, Globerson S: Project Management, Prentice Hall, 1994.
Milanovic D Lj, Dubonjic R: “Use of the Elasticity of Net Present Value in Risk Analysis of Engineering Investments Projects”, FME Transactions, Vol 33, No 1, 2005., FME, pp. 47-51.

Engineering Economy

ID: MSc-0569
teaching professor: Милановић Љ. Драган
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: industrial engineering

goals

The objectives of this course are to guide students in engineering and the respective economic and financial processes and to inform them of the relations, connections and rules by which these processes take place in the generation and selection of optimal variant of projects for the overall success in achieving development goals of enterprise

learning outcomes

Mastering this program, student obtains the following general skills: analysis and synthesis and forecasting solutions and consequences; mastery of methods, procedures and processes of research; application of knowledge in practice.
He also obtains the following subject-specific skills: solving practical problems using scientific methods and procedures, linking basic knowledge in various fields and their applications

theoretical teaching

Introduction to analysis and evaluation of the effectiveness of projects; contents of the investment study; analysis of the solvency of company- investor; market analysis; analysis of technical and technological aspects of investment; analysis of organizational and managerial aspects of investment; ecological analysis and economic-financial analysis.
Time value of money; methods of calculating interest and the calculation of interest formula.
Methods of project evaluation: method of net present value, method of annual equivalent worth, method of IRR, MAPI method , benefit-cost analysis.
Depreciation - types of depreciation, methods of calculating depreciation.
Cost Analysis - classification of costs from an engineering standpoint.
A concrete analysis of projects: analysis of operational, investment and financial activities of the project; the influence of inflation and risk on project analysis.

practical teaching

1. auditory exercise: recovering material from the first hours of lectures with detailed analysis of contents of the investment study . 2. auditory exercise: technical, technological and ecological aspects of the project and 3. auditory exercise: economic-financial analysis of the investment study.
1. computational practice: tasks of the time value of money and the NPV method.
2. computational practice: tasks of the annual equivalent worth method. 3. computational practice: tasks of the method of IRR. 4. computational practice: tasks of the MAPI method and depreciation. 5. computational practice: tasks of cost analysis. 6. computational practice: tasks of analysis of operational, investment and financial activities of the project and analysis of projects under the influence of inflation. 7. computational practice: tasks of analysis of projects under the influence of risk.

prerequisite

The student must be enrolled in the first year of academic studies (the second semester).

learning resources

1.Handouts
2.Dubonjic R, Milanovic Lj D: Engineering Economy, Publishing Centre of Industrial Management Plus, Krusevac, 2005. (in Serbian)
3.Milanovic Lj D and others: Making of investment study, Belgrade, 1998. (in Serbian)

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 8
laboratory exercises: 0
calculation tasks: 16
seminar works: 0
project design: 0
consultations: 6
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 4
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 6
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 35
laboratory exercises: 0
calculation tasks: 30
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

Park, Ch: Contemporary Engineering Economics, Addison-Wesley Publishing Company, 1993.
Young, D.: Modern engineering economy, John Wiley & Sons, 1993.
Shtub A, Bard J, Globerson S: Project Management, Prentice Hall, 1994.
Milanović D Lj, Dubonjić R: "Use of the Elasticity of Net Present Value in Risk Analysis of Engineering Investments Projects", FME Transactions, Vol 33, No 1, 2005., FME, pp. 47-51.

Ergonomic design

ID: MSc-0171
teaching professor: Жуњић Г. Александар
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: industrial engineering

goals

Students should acquire specific practical skills that include an integrated ergonomic approach for the design of a comprehensive solution to different problems. The aim of this course is the acquisition of basic academic knowledge in the field of ergonomic design, which can be used for design of different products, as well as for redesigning and improvement on the system man - machine.

learning outcomes

It is expected that acquired knowledge students can use in daily work and practice, bearing in mind that in almost all branches of industry there is a need for designing, which includes the human factor. By mastering of the ergonomic design program, the student acquires the ability to solve all aspects of the various engineering problems by applying science-based ergonomic methods, techniques and recommendations.

theoretical teaching

Introduction to ergonomic design. Application of the ergonomic approach to designing of systems. Application of ergonomic tools for managing and implementation of engineering projects. Design of indicators. Design of controls. Application of ergonomics in workplace design. Design of environmental conditions. Application of anthropometry for designing of products. Ergonomic product design and evaluation of interface. Comfort and safety of vehicles. Application of ergonomic research methods. Discussion of good and bad product design solutions from the ergonomic standpoint. Case studies.

practical teaching

Writing of a seminar paper - each student selects one of a number of topics, for which he is writing seminar paper in the form of professional work. The first laboratory exercise: Readability of indicators - the criteria for the assessment of readability are presented and testing of analogue visual displays is performed in the laboratory conditions. The first project task - VDT workplace design. Auditory exercise - Application of ergonomic checklists. The second project task - Application of anthropometry in designing of products. The second laboratory exercise: Assessment of conditions of working surroundings - the criteria for assessing of conditions of working surroundings are presented and carries out the assessment of the conditions of the working surroundings at the selected workplace. Presentation (workshop): Application of software in ergonomic design.

prerequisite

The necessary condition for attending the course is that the student have enrolled to the appropriate semester.

learning resources

Žunjić A. and Ćulić M., 2007, Practicum for laboratory exercises in industrial ergonomics, Faculty of Mechanical engineering, Belgrade - available in the bookstore and library of the Faculty of Mechanical Engineering. Klarin M. and Žunjić A., 2007, Industrial ergonomics, textbook, Faculty of Mechanical engineering, Belgrade - available in the bookstore and library of the Faculty of Mechanical Engineering. Tachistoscope, sound level meter, konimeter, psychrometer, lux meter, anthropometric measuring equipment, available in the lab. 417. CAD workstation, available in the lab. 455. CAD software package Catia, available in the lab. 455.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 1
laboratory exercises: 9
calculation tasks: 0
seminar works: 8
project design: 7
consultations: 2
discussion and workshop: 3
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 4
check and assessment of seminar works: 2
check and assessment of projects: 4
colloquium, with assessment: 0
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 0
laboratory exercises: 20
calculation tasks: 0
seminar works: 20
project design: 20
final exam: 30
requirements to take the exam (number of points): 40

references

Handbook of human factors and ergonomics in consumer product design: uses and applications, 2011, Edited by Karwowski W., Soares M. and Stanton N., Taylor & Francis, London.
Sanders M. and McCormick E., 1993, Human factors in engineering and design, McGraw - Hill, Singapore.
Woodson W., 1981, Human factors design handbook, McGraw-Hill Book Company, New York.

Ergonomic designing

ID: MSc-0417
teaching professor: Жуњић Г. Александар
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: industrial engineering

goals

The aim of this course is the acquisition of basic academic knowledge in the field of ergonomic designing, which can be used for designing of different products, as well as for redesigning and improvement of system man - machine - environment. Students should acquire specific practical skills that include an integrated ergonomic approach for the purpose of a comprehensive settlement of various designing problems.

learning outcomes

By mastering of the ergonomic designing program, the student acquires the ability to solve all aspects of the various engineering problems by applying science-based ergonomic methods, techniques and recommendations. It is expected that acquired knowledge students can use in daily work and practice, bearing in mind that in almost all branches of industry there is a need for designing, which includes the human factor.

theoretical teaching

Introduction to ergonomic designing. The ergonomic approach to designing of complex systems. Ergonomic tools for managing and implementation of engineering projects. Designing of indicators. Designing of controls. Workplace designing. Designing of conditions of the working environment. Computer-supported ergonomic designing (CSED). Application of anthropometry in the ergonomic designing. Ergonomic product designing and evaluation of interfaces. Safety and comfort of vehicles. Ergonomic research methods. Discussion of good and bad project solutions of products. Ergonomic case studies.

practical teaching

Writing of a seminar paper - each student selects one of a number of topics, for which he is writing seminar paper in the form of professional work. The first laboratory exercise: Readability of analogue visual displays - the criteria for the assessment of readability are presented and testing of analogue visual displays is performed in the laboratory conditions. The first project task - VDT workplace designing. Auditory exercise - Ergonomic checklists. The second project task - Application of anthropometry in designing. The second laboratory exercise: Assessment of conditions of working environment - the criteria for assessing of conditions of working environment are presented and carries out the assessment of the conditions of the working environment at the selected workplace. Presentation (workshop): Application of software in ergonomic designing.

prerequisite

The necessary condition for attending the course is that the student have enrolled to the appropriate semester.

learning resources

Žunjić A. and Ćulić M., 2007, Practicum for laboratory exercises in industrial ergonomics, Faculty of Mechanical engineering, Belgrade - available in the bookstore and library of the Faculty of Mechanical Engineering. Klarin M. and Žunjić A., 2007, Industrial ergonomics, textbook, Faculty of Mechanical engineering, Belgrade - available in the bookstore and library of the Faculty of Mechanical Engineering. Tachistoscope, sound level meter, konimeter, psychrometer, lux meter, anthropometric measuring equipment, available in the lab. 417. CAD workstation, available in the lab. 455. CAD software package Catia, available in the lab. 455.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 1
laboratory exercises: 9
calculation tasks: 0
seminar works: 8
project design: 7
consultations: 2
discussion and workshop: 3
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 4
check and assessment of seminar works: 2
check and assessment of projects: 4
colloquium, with assessment: 0
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 0
laboratory exercises: 20
calculation tasks: 0
seminar works: 20
project design: 20
final exam: 30
requirements to take the exam (number of points): 40

references

Handbook of human factors and ergonomics in consumer product design: uses and applications, 2011, Edited by Karwowski W., Soares M. and Stanton N., Taylor & Francis, London.
Sanders M. and McCormick E., 1993, Human factors in engineering and design, McGraw - Hill, Singapore.
Woodson W., 1981, Human factors design handbook, McGraw-Hill Book Company, New York.

Industrial engineering practice 2

ID: MSc-0438
teaching professor: Милановић Љ. Драган
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 1
final exam: seminar works
parent department: industrial engineering

goals

The goal of course is to introduce the production processes in industrial companies and to acquire practical knowledge in the field of work organization and economics of the enterprise. In this course students will be familiar with the work of diagnosing and raising the general level of organization of enterprises and economic business of enterprises. Methods and techniques will be of use to students in their daily performance of engineering jobs.

learning outcomes

Mastering of this course students will learn about the production processes in the enterprise, internal transport, terotechnological processes, function of production planning, procurement operations and material storage, economic-financial business of firm etc...

theoretical teaching

The role and importance of professional practice of industrial engineering. Organizing the departure of students in the metal processing factory complex in Belgrade, where students acquire the necessary knowledge and practical skills in the field of planning and organization of production processes and economic basis for decision making in enterprises. Student acquires the theoretical background in the field of scientific disciplines, such as the organization of production processes, terotechnology, the economics of enterprise etc... He also becomes familiar with the possibilities of using modern methods and techniques in the enterprise to improve production and development company.

practical teaching

Product range and type of production in particular company. The recording and analysis of existing organizational structure. Analysis of factors influencing the design of the organizational structure. Selection of the optimal strategy for solving structural, managerial and functional problems in the enterprise. Overview and analysis of abundant methods for planning and monitoring of production. Introduction to maintenance system. Overview and analysis of abundant methods for investment decision-making in the enterprise. Introduction to Income Statement.

prerequisite

Student must be enrolled in the third semester of academic study

learning resources

1. Bulat V: Production organization. FME, Belgrade, 1999. (in Serbian)
2. Jovanovic T, Milanovic D D, Spasojevic V: Modern organization and production managing, Belgrade, 1996. (in Serbian)

number of hours

total number of hours: 46

active teaching (theoretical)

lectures: 46

active teaching (practical)

auditory exercises: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 0
final exam: 0

assessment of knowledge (maximum number of points - 100)

feedback during course study: 70
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

Dubonjic R, Milanovic Lj D: Engineering Economy, Publishing Centre of Industrial Management Plus, Krusevac, 2005. (in Serbian)
Klarin M: Production planning and managing, Industrial engineering I, Belgrade, 1996. (in Serbian)

Industrial logistic

ID: MSc-0416
teaching professor: Петровић Б. Душан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: industrial engineering

goals

Achieving competency and academic skills in the process of industrial system design. Special emphasis is focused on development of creative skills and overwhelm with specific practical skills needed for professional practice using operational research methods, procedures of analysis and synthesis for obtaining final goal which is optimal practical solution.

learning outcomes

Curriculum overcome enables converge of the following skills: analysis, synthesis and prediction of solutions in design process based on knowledge applying in practice using professional ethics as well as development of crucial and self-critical thinking and approach.

theoretical teaching

Logistic system in industrial environment (role of logistic system in industry, functions which system must achieved and its benefit for industry). Elements of logistic system (production based on end user demand, distribution and warehouse systems). Basic sub-systems of logistic system (production with defined capacity, transport with defined technology and distribution warehouse system). Place and role of the warehouse in logistic system. Application and effects of application of logistic systems in industry (territory coverage with defining location of production and end user, reduction of transport and storage costs and increase of flexibility towards end user).

practical teaching

Audit lessons (Introduction in design process for defined logistic system – defining elements of logistic system and basic sub-systems for chosen logistic system. Introduction in warehouse design of palletized goods – defining of: reception area, main warehouse, distribution – order picking, shipping and warehouse management system).
Project workmanship (Determining of the optimal location of the logistic system in macro surrounding – positioning of warehouse regarding to production and end user as a function of transport system. Project of warehouse for palletized goods - defining of: packing and capacity, work technology, layout, reception and shipping and warehouse management system).

prerequisite

There is no special conditions needed for course attending

learning resources

1. Petrovic, D.: Lecture handouts, Faculty of Mechanical engineering Belgrade, Belgrade, 2008-2011.
2. Bugaric, U., Petrovic, D.: Servicing system modelling, Faculty of Mechanical engineering Belgrade, Belgrade, 2011.
3. Zrnić, Đ., Petrović, D.: Factory design – assortment of solved examples, Faculty of

Mechanical engineering Belgrade, Belgrade, 1990.
4. Zrnić, Đ., Petrović, D.: Stochastic process in transport, Faculty of Mechanical engineering Belgrade, Belgrade, 1994.
5. Bloomberg, D. J., LeMay, S. B., Hanna, J. B.: Logistics, Prentice Hall, New York, 2002.
6. Practical instruction in industrial environment.
7. Personal computers.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 5
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 25
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 6
colloquium, with assessment: 4
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 20
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 40
final exam: 30
requirements to take the exam (number of points): 30

references

Asimow, M.: Introduction to Design, Prentice-Hall, Englewood Cliffs, New Jersey, 1962.
Hall, A. D.: A methodology for systems engineering, Van Nostrand, Princeton, New Jersey, 1962.
Cooper, B. R.: Introduction to queueing theory (second edition), Elsevier North Holland, New York, 1981.
Muther, R.: Systematic Layout Planning, Cahners Publishing Company Inc., Boston, 1973.

Industrial Management

ID: MSc-0419
teaching professor: Покрајац У. Слободан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: industrial engineering

goals

The aim of this subject is that students get know basic principles, methods and techniques of management in general, and especially in industrial enterprises. The aim is that students adopt knowledge and skills which will be solid basis for further requiring competences for autonomous and responsible participation in processes of business decisions in contemporary conditions.

learning outcomes

To get know of content Industrial Management the students get know modern knowledge from theory and practice of management in general, and especially in industrial enterprises, when accent is on achievement of competence to strengthen innovation as a key factor of competitivity in turbulent business environment, local and international.

theoretical teaching

Management and entrepreneurship: external environment, social responsibility and business ethics. Types of managers. Manager's roles. Industry and its transformations. Planning, strategic planning i strategic management. Forecasting and prognostication. Organization and organizing as managerial resources. Decision making as a problem solving process. Human resources as a asset of company. Conflicts and conflict management. Management of creativity and innovations. Basic principles of knowledge management. Leading. Styles of leading. Motivation. Systems of communications. Controlling as management feed-back. Industrial project management. Quality as management variable. Ecology management. Globalization and management.

practical teaching

The practical work is consisted from discussion and workshops with special topics as well as characteristic industrial cases from local and word practice. Special attention will be paid to the problem of innovations, especially to technological innovations as a factor of competitivity. Also, the questions of transition of management into leadership will be wider discussed, as well as other questions from contemporary business management. Beside that, practical work is used for preparation of seminar paper.

prerequisite

At least 50 points, when points from the practical exams are especially important.

learning resources

Beside cited literature and handouts, chosen internet links, as well as special prepared business cases, from local and the international practice, will be used.

Slobodan Pokrajac, Dragica Tomić, Management, (in Serbian), Alfa-graf, Novi Sad, 2011

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 10
laboratory exercises: 0
calculation tasks: 0
seminar works: 10
project design: 0
consultations: 10
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 5
check and assessment of projects: 0
colloquium, with assessment: 5
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 20
test/colloquium: 40
laboratory exercises: 0
calculation tasks: 0
seminar works: 10
project design: 0
final exam: 30
requirements to take the exam (number of points): 50

references

C.M.Chang, Engineering Management: Challenges in the New Millenium, Pearson Prentice Hall, New Jersey, 2005
John Jeston and Johan Nelis, Business Process Management: Practical Guidelines to Successful Implementations, Butterworth-Heinemann, 2006

Management Information Systems

ID: MSc-0523
teaching professor: Мисита Ж. Мирјана
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: industrial engineering

goals

The aim of this course is to introduce students to contemporary theoretical and practical aspects of management information systems. Students need to acquire practical knowledge and skills that will enable them to enhance the quality of decisions in the field of industrial engineering, by using the contemporary software tools.

learning outcomes

After passing the exam the student understands the importance of using MIS in solving management problems. Student knows to apply sofware tools: decision support systems, expert systems, and hybrid systems in solving complex management problems.

theoretical teaching

The term of Management information system (MIS). Decision-making process. Methods and techniques used in decision-making by managers. New IT and Web applications in functional areas. Executive information systems. Decision support systems. Knowledge management. Intelligent support systems. Expert systems. Other intelligent systems. Hybrid systems. Contemporary software in management.

practical teaching

Task 1. By using software tools - decision support systems it is necessary to design models, generate a hierarchy of criteria and alternatives by introducing of qualitative and quantitative scales, introducing uncertainty, or by using functions to describe real problems in manufacturing practices. Conduct ranking according to the AHP or SMART methods. Sensitivity Analysis. Presentation of project assignment.
Task 2. By using an expert system shell it is necessary to design a knowledge base for the real engineering problem, link the production rules. Test the expert system. Presentation of project assignment.
Task 3. Connect the two previous project tasks and form a hybrid system. Presentation of project assignment.

prerequisite

Enrolled 1st semester of the Master study.

learning resources

1. Book: Milanovic D. Dragan, Misita Mirjana, Information systems for management and decision making, Faculty of Mechanical Engineering, Belgrade, 2008.
2. Handouts,
3. Computer classroom,
4. Software packages: decision support system and expert system.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 20

active teaching (practical)

auditory exercises: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 40
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 5
colloquium, with assessment: 0
test, with assessment: 5
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 20
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 30
final exam: 40
requirements to take the exam (number of points): 10

references

Milanovic D. Dragan, Misita Mirjana, Information systems for management and decision making, Faculty of Mechanical Engineering, Belgrade, 2008
Turban E., Aronson J., Decision Support and Business Intelligence Systems, Pearson International Edition, 9th edition, 2010.

Man - machine system design

ID: MSc-0520
teaching professor: Жуњић Г. Александар
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 4
final exam: oral
parent department: industrial engineering

goals

The aim of this course is the acquisition of basic academic knowledge in the field of man - machine system design, which can be used for designing of different products and industrial systems, as well as for redesigning and improvement of system man - machine - environment. Students should acquire specific practical skills that include an integrated ergonomic approach for the purpose of a comprehensive settlement of various designing problems.

learning outcomes

By mastering of the man - machine system design program, the student acquires the ability to solve all aspects of the various engineering problems by applying science-based ergonomic methods, techniques and recommendations. It is expected that acquired knowledge students can use in daily work and practice, bearing in mind that in almost all branches of industry there is a need for designing, which includes the human factor.

theoretical teaching

Mechanical hazards and safe operation of machinery. Analysis of risk in the system man - machine and their prevention. Safety and reliability of products. Management of errors in the man - machine system. Ergonomics of designing of technical and project documentation. Recommendations for designing of technical and project documentation.

practical teaching

Improving of the safety of machines (auditory exercise). Writing of a seminar paper - each student selects one of a number of topics, for which he is writing seminar paper. Basic procedures for identifying and analyzing hazards originating from equipment and facilities (auditory exercise). Recommendations for the design of safe products (auditory exercise). Classification and prediction of errors in the man - machine system (auditory exercise). The first project task - Identification of hazards in the workplace. Examples of poor ergonomic design solutions of products - case studies (auditory exercise). The second project task - Ergonomic assessment of design solutions for the manuals. Risk assessment in the man - machine system (auditory exercise).

prerequisite

The necessary condition for attending the course is that the student have enrolled to the appropriate semester.

learning resources

Žunjić A. and Ćulić M., 2007, Practicum for laboratory exercises in industrial ergonomics, Faculty of Mechanical engineering, Belgrade - available in the bookstore and library of the Faculty of Mechanical Engineering. Klarin M. and Žunjić A., 2007, Industrial ergonomics, textbook, Faculty of Mechanical engineering, Belgrade - available in the bookstore and library of the Faculty of Mechanical Engineering.

number of hours

total number of hours: 45

active teaching (theoretical)

lectures: 12

active teaching (practical)

auditory exercises: 12
laboratory exercises: 0
calculation tasks: 0
seminar works: 2
project design: 5
consultations: 6
discussion and workshop: 2
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 1
check and assessment of projects: 2
colloquium, with assessment: 0
test, with assessment: 0
final exam: 3

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 20
project design: 40
final exam: 30
requirements to take the exam (number of points): 40

references

Handbook of human factors and ergonomics in consumer product design: uses and applications, Edited by Karwowski W., Soares M. and Stanton N., Taylor & Francis, London.
Sanders M. and McCormick E., 1993, Human factors in engineering and design, McGraw - Hill, Singapore.
Woodson W., 1981, Human factors design handbook, McGraw-Hill Book Company, New York.

Operations Research

ID: MSc-0421
teaching professor: Бугарић С. Угљеша
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: industrial engineering

goals

Course goal is overwhelm with academic and scientific methods and quantitative techniques for obtaining alternative (optimal) solutions of real world problems on which basis user can perform analysis and synthesis of given solutions, make decision and predict consequences.

learning outcomes

Solution of concrete problems with application of scientific methods, procedures and techniques using analysis, synthesis and prediction of solutions and consequences as well as overwhelm with methods, procedures and research processes and application of knowledge (gained skills) in practice.

theoretical teaching

Introduction. Problem classification. Linear programming (graphical solution, simplex method, dual theory, sensitivity analysis). Transportation problem (open and closed). Nonlinear programming. Dynamical programming, Project management (structure analysis, time analysis using PERT/CPM, critical path, cost analysis – PERT/Cost). Service systems – Queuing theory (queuing theory models – single and multi server with out and with partial and complete help between servers, with finite and infinite source of customers, optimisation of service systems). Simulation of service systems (approach to simulation, Monte Carlo method, generation of random numbers, processing and presentation of simulation results). Decision analysis. Forecasting (forecasting methods).

practical teaching

Audit lessons (examples of linear programming, transportation problem, nonlinear programming, dynamical programming. Examples of project management – structure analysis, time analysis cost analysis. Examples of application of queuing theory models – finite and infinite source of customers, single and multi server without and with partial and complete help between servers. Examples of service system optimisation. Application of simulation and Monte Carlo method in analysis and modelling of service systems. Examples from area of decision making and forecasting.).
Laboratory work (the use of adequate software).

prerequisite

There is no special conditions needed for course attending

learning resources

1. Bugaric, U.: Lecture handouts, Faculty of Mechanical engineering Belgrade, Belgrade, 2008-2011.
2. Bugaric, U., Petrovic, D.: Servicing system modelling, Faculty of Mechanical engineering Belgrade, Belgrade, 2011.

3. Bugaric, U.: Methodology for analysis of single position machines work, Foundation Andrejevic, Belgrade, 2003.
4. Software: QtsPlus 3.0 (Queuing theory software Plus).
5. Software: QSopt Version 1.0 (Linear programming problems).
6. Software: IOR Tutorial (Interactive Operations Research).
7. Software: MS – Project (Project management).
8. Personal computers.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 21
laboratory exercises: 9
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 1
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 9
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 40
laboratory exercises: 20
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

Petrić, J.: Operations Research (book 1 & 2), Savremena administracija, Belgrade, 1990.
Žiljak, V.: Computer simulation, Školska knjiga, Zagreb, 1982.
Clymer, J. R.: Systems analysis using simulation and Markov models, Prentice-Hall International Inc., 1990.
Churchman, C. W., Ackoff, R. L., Arnoff, E. L.: Introduction to Operations research, John Willey & Sons Inc., 1957.
Hillier, F. S., Lieberman, G. J.: Introduction to operations research (seventh edition), McGraw-Hill, New York, 2000.

Organization Design

ID: MSc-0574
teaching professor: Спасојевић-Бркић К. Весна
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: industrial engineering

goals

The aim of this course is to acquire the necessary knowledge and practical skills that will enable students to define the interdependence of the elements of organizational structure and processes so that in a given or anticipated situation organizationaly shaped organizational system (enterprise or its parts) achieves the persued objectives and goals.

learning outcomes

Outcomes of thid course arethe following: a) The acquisition of theoretical and practical knowledge in the field of intentional and controlled development and changes in the organization to improve efficiency and effectiveness, and working conditions in the organization b) Alignment of organizational and technical / technological factors and changing of organizational culture and climate and c) Setting the optimal model organization with respect to the objectives and available resources.By the end of the Organisation Design course student will be able to:
-tackle an organisation design project
-sequence and approach the design effectively
-apply various tools and techniques to make good organisation
-design decisions
-control the consequences and risks of design changes
-recognise and address design project blockers and challenges.

theoretical teaching

Basic concepts of the design of organizations. Elements of organizational theory. Development of organizational theory. The concepts of organizational design. Directions of the past development of organizational theory. Situational model. Mintzberg`s model. Wilson`s model.Inkson`s model. Lawrence & Lorshov`s model. Frieblander`s model. Denning-Brown`s model. HPI model. Managerial grid model. Grainer`s model. Experience of local authors in designing the organization.Empirical organizational, technical, technological and cultural changes in organizational systems.

practical teaching

Data collection about the business and production operations relevant factors in real conditions. The analysis of situational factors (environment, size, age and type of company). Analysis of strategic variables (growth and development strategies). Analysis of structural factors (technology 'type of production and organizational structure). Analysis of behavioral variables (organizational culture and climate). The analysis of business performances (development, operational and financial performance of companies). The proposal of new macro and micro organizational structure of the company. Check the proposed solution of the organizational structure OrgCon software package.

prerequisite

Students need to enroll 9th semester.

learning resources

1. Spasojevic Brkic V., Contingency theory and Quality Management, Faculty of Mechanical Engineering, Belgrade, 2009.
2. Jovanovic T., Milanovic D. D., V Spasojevic., Modern organization and management of production, Faculty of Mechanical Engineering,Belgrade. 1996.
3.Klarin M., Industrial Engineering, Volume 1, The organization and planning of production processes,Faculty of Mechanical Engineering, Belgrade, 1996.
4.Cvijanović J., Designing Organizations, Institute of Economics, 1992.
5. Van de Ven A, Ferry D. Measuring and Assessing Organizations, John Wiley & Sons, New York, 2000.
6. Handout

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 3
laboratory exercises: 0
calculation tasks: 6
seminar works: 0
project design: 20
consultations: 1
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 1
check and assessment of projects: 5
colloquium, with assessment: 4
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 20
project design: 35
final exam: 35
requirements to take the exam (number of points): 30

references

1. Spasojevic Brkic V., Contingency theory and Quality Management, Faculty of Mechanical Engineering, Belgrade, 2009.
2. Jovanovic T., Milanovic D. D., V Spasojevic., Modern organization and management of production, Faculty of Mechanical Engineering,Belgrade. 1996.
3.Klarin M., Industrial Engineering, Volume 1, The organization and planning of production processes,Faculty of Mechanical Engineering, Belgrade, 1996.
4.Cvijanović J., Designing Organizations, Institute of Economics, 1992.
5. Van de Ven A., Ferry D., MEASURING AND ASSESSING ORGANIZATIONS, John Wiley & Sons, New York, 2000.

Production and Operations Management 2

ID: MSc-0413
teaching professor: Милановић Д. Драган
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: industrial engineering

goals

Studying the management process of business-production system in its interaction with the environment.Identification of problems in business-production systems and the process of solving them, with implementation procedure. Investigation and design of production macro and micro organizational structure. Management of business-production system and provision of all resources necessary for production normal operation.

learning outcomes

Acquisition of knowledge and skills necessary for successful management of business-production systems. In addition, students are able to design production program and production processes. It is of importance their ability to analytically view the complexity of the problem and to solve it by applying contemporary methods.

theoretical teaching

Complex optimization of business-production systems in thier interaction with the environment. Classification of business-production systems by the character of the technological process. Types of production organizational structure. Methods and techniques for scanning the current state of engineering-technological basics of production. Business-production problems and the process of solving them, with implementation procedure. Organizational structure of production and accessory units, operation and operational relations with organizational unit. Time management as an irretrievable resource, production cycle and delivery terms, flow coefficient, internal reserves and possibility of utilizing them. Design of macro, micro and intra organizational structure. Static and dynamic aspect with contents of jobs per organizational unit. Cybernetic model design for direct organization of production preparation and provision of all resources needed for normal operation of all work places. Methods and techniques of work place scanning.

practical teaching

Exercises are realized through project task in the enterprise. Project task should establish the most important organizational problems in an enterprise and propose how to solve them in order to improve organizational level in general and rationalize business operations and production. The design of jobs at work place is stressed. Job description, work conditions, job classification and work place matrix. Students are supposed to make concrete proposal for rationalization and improvement of operation of certain organizational wholes in business-production system by applying contemporary methods and techniques of industrial management.

prerequisite

Production and Operations Management 1 (not obligatory); semester certified.

learning resources

The enterprise where the project is to be realized, so that students get familiarized with realistic conditions of production, scan the current state-of-art and collect documentation. The Chair allows students to use equipment for scanning work conditions at work place. Use of additional literature is recommendable, depending on the project theme.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 25
consultations: 5
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 5
colloquium, with assessment: 5
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 30
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 30
final exam: 30
requirements to take the exam (number of points): 30

references

V.Bulat: Organization of production, FME, Belgrade, 1999 /In Serbian/
T.Jovanovic, D.D.Milanovic, V.Spasojevic: Contemporary organization of production management,FME,Belgrade, 1996 /In Serbian/
T.Jovanovic, D.D.Milanovic, Z.Veljkovic: Collection of tasks in quantitative methods, FME, Belgrade, 1996 /In Serbian/

Quantitative Methods

ID: MSc-0415
teaching professor: Вељковић А. Зорица
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: industrial engineering

goals

Goals of the course are introduction of basic and statistical methods for engineering practice. Main goals of the course is identification of problems, methods for their solving, defying problem solving procedures and systems for decision making, based on obtained results, i.e. interpretation of numerical results for use in practice.

learning outcomes

After successfully completed course, students should be able to define the problem, identify and apply adequate statistical procedures and obtain competent answers. During the course students master the procedures for use of adequate statistical methods. It is expected that students could be able for interpretation of statistical results for their use in practical problems.

theoretical teaching

Course include following subjects: Basic definitions in statistics; Descriptive statistics; Basics of Discrete and continuous probability distributions for random variables. Parameter confidence intervals; Parameter tests of hypothesis that include one and two sample tests for means, proportion and variance. Nonparametric testing include goodness of fit by Kolmogorov test, comparison tests for distributions such as Mann Whitney test, Kolmogorov-Smirnov test and tests for median; One-way and two-way analysis of variance; Simple linear and multiple regression and correlation and nonparametric regression.

practical teaching

Exercises follow the contents of lectures by examples and problem solving in order to identify and set the problem adequately, followed by identification of appropriate statistical method and procedure up to interpretation of the results and drawing the conclusions. Exercises are based on examples that teach students to use procedures algorithms and tables with formulas for better and efficient problem solving. Proper practical interpretation of results and drawing of conclusions is emphases.

prerequisite

According the Industrial Engineering curriculum

learning resources

All materials for successful following of the course - handouts and other materials are distributed to students before lectures in electronic form.

Radojević S, Veljković Z, Kvantitativne metode, CD. MF

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 20

active teaching (practical)

auditory exercises: 20
laboratory exercises: 2
calculation tasks: 18
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 8
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 6
test, with assessment: 0
final exam: 1

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 50
laboratory exercises: 0
calculation tasks: 15
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 31

references

Radojević S, Veljković Z, Kvantitativne metode, CD. MF
Montgomery, DC, Runger, GC Applied Statistics and Probability for Engineers, Fourth Edition, Wiley, 2007

Risk management in Terotechnology

ID: MSc-0513
teaching professor: Спасојевић-Бркић К. Весна
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: industrial engineering

goals

The aim of this course is to acquire the necessary knowledge and practical skills that will enable students to apply maintenance systems based on risk management, due to knowledge in the identification, analysis, risk assessment and decision-making on the basis of these facts.

learning outcomes

Outcomes of this course are the following: a) The acquisition of theoretical and practical knowledge in the field of basic systems, methods and strategies of machinery and equipment b) Introduction to the methods of maintenance based on risk, c) RIMAP and RCM models, and d) Application of RCM/RIMAP model in practice.

theoretical teaching

Introduction to terotechnology. Terotechnological procedures, operations and technologies. Aims and objectives of terotechnological activities. The principles of maintenance. Maintenance policy. Maintenance systems. The organizational structure of maintenance function. Maintenance methods and strategies. Maintenance methods based on risk. Maintaining the reliability - Reliability Centered Manintenance - RCM. Qualitative risk assessment. Risk-based Inspection - RBI. The concept of risk-based maintenance - RBIM. Risk Based Life Cycle Management of technical resources - RBLM. Based management rizoku - RBM. Maintenance procedures based on risk - RIMAP. Risk management tools. Application of risk management in national industrial practice.

practical teaching

Collection and systematization of data collected in companies. Collection and evaluation of data on individual risks. Preliminary risk matrix. Calculation of individual riskc. Risk matrix. Preliminary evaluation of the possible scenarios of origin effects. Risk tools application. Detailed analysis of one or more of the selected scenarios, including probability analysis to achieve them. Detailed technical analysis of possible consequences of different scenarios. The overall analysis of possible consequences and analysis in terms of insurance and reinsurance.

prerequisite

Enrolled semester.

learning resources

1. Klarin M., Ivanovic G., Stanojevic P., Raicevic R. , Principles of Terotechnological Procedures, Faculty of Mechanical Engineering, Belgrade, 1994.
2. Smith D., Reliability, Maintainability and Risk - Practical methods for engineers, Elsevier Butterworth-Heinemann, Oxford, 2005.
3. Zio E., AN INTRODUCTION TO THE BASICS OF RELIABlTY and RISK ANALYSIS, World Scientific Publishing Co., 2007.

4.Handout

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 20

active teaching (practical)

auditory exercises: 3
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 36
consultations: 1
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 5
colloquium, with assessment: 5
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 55
final exam: 35
requirements to take the exam (number of points): 20

references

1. Klarin M., Ivanovic G., Stanojevic P., Raicevic R. , Principles of Terotechnological Procedures, Faculty of Mechanical Engineering, Belgrade, 1994.
2. Smith D., Reliability, Maintainability and Risk - Practical methods for engineers, Elsevier Butterworth-Heinemann, Oxford, 2005.
3. Zio E., AN INTRODUCTION TO THE BASICS OF RELIABlTY and RISK ANALYSIS, World Scientific Publishing Co., 2007.

Modern Quality Approaches

ID: MSc-0524
teaching professor: Вељковић А. Зорица
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 2
final exam: written
parent department: industrial engineering

goals

Purpose of the course is to introduce students to concepts and importance of quality in enterprises. Basic principles, methods and approaches are introduced to students. Three main topics are Total Quality Management, ISO 9001:2008 standards and Six Sigma.

learning outcomes

After successfully completed projects and course, students should be able to use basic managerial and statistical quality methods. Students are informed about modern and current trends in quality, methods and software for quality improvement, with a possibility of applications.

theoretical teaching

The course include following subjects: Definitions and role of quality in enterprises, from the aspects of organizations and production; Defining real needs for quality and customer view; Basic quality tools, basic management quality tools. Basic statistics tools in quality; Three major approaches TQM - Total Quality Management, Quality standards, especially ISO 9001:2008, and System Six Sigma. TQM include Deming's approach, product characteristics, benchmarking, QFD, kayzen, 5s, etc. Quality standards are introduced to students through their structure, documentation, requests, advantages and limitations. System Six Sigma approach is represented with basic methodology DMAIC and consequent methods such as TRIZ, methods from TQM, Taguchi methods, Statistical methods etc, for every phase of DMAIC. Concept of data driven decision making is elaborated.

practical teaching

Students are introduced to software for quality methods. Main goal for students is the project based on practical examples and literature.

prerequisite

Course in statistics such as Quantitative methods or Probability and Statistics

learning resources

All materials for successful following of the course - handouts and other materials are distributed to students before lectures in electronic form. Part of the literature for projects.

number of hours

total number of hours: 30

active teaching (theoretical)

lectures: 10

active teaching (practical)

auditory exercises: 2
laboratory exercises: 3
calculation tasks: 0
seminar works: 8
project design: 0
consultations: 2
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 4
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 0
final exam: 1

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 60
project design: 0
final exam: 30
requirements to take the exam (number of points): 31

references

Popovic, B, Klarin M, (2003)Quality of Design, MF
Stapenhurst T(2005) Mastering Statistical Process Control A Handbook for Performance Improvement Using Cases,Elsviere
Schlickman, JJ (2003) ISO 9001: 2000 Quality Management System Design, Artech House
Pyzdek, T (2003) The Six Sigma Handbook: The Complete Guide for Greenbelts, Blackbelts, and Managers at All Levels, McGraw Hill

ID: MSc-0593
teaching professor: Петровић Б. Душан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: industrial engineering

goals

learning outcomes

theoretical teaching

practical teaching

prerequisite

learning resources

number of hours

total number of hours: 0

active teaching (theoretical)

lectures: 0

active teaching (practical)

auditory exercises: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 0
final exam: 0

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0

final exam: 0
requirements to take the exam (number of points): 0

references

information technologies

Algorithms and Data Structures
Basics of operating systems
C/C++
Computer Networks
Designing software for mechanical engineers
Digital system design
Distributed Systems in Mechanical Engineering
Information integration of business functions 2
Information Technology Projects Evaluation
Introduction to engineering simulations
Object oriented paradigm
Professional Practice M - MIT
Programmable Control System
SQL
Statistical analysis in mechanical engineering
The Data Exquisite in Mechanical Engineering
Methods optimization

Algorithms and Data Structures

ID: MSc-0390
teaching professor: Бенгин Ч. Александар
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: information technologies

goals

• Basic facts of algorithm theory.
• Abstract data type and basic implementation.
• Data structures in mechanical engineering.
• Using standard algorithms in solving simple problems in mechanical engineering.

learning outcomes

After successful completion of the program provided for in this case the student can:
• To find data structure to solve the problem.
• Use data structures and standard algorithms in solving simple problems in mechanical engineering.
• To find suboptimal algorithm to solve smple problems in mechanical engineering.
• To use standard algorithms to solve complex problems in mechanical engineering.

theoretical teaching

Basic facts about algorithms. Basic facts about abstract data type. Array. Lists. Buffers. Stack. Queue. Trees. Binary tree. Binary hip. Set. Hash. Dictionary. Varies sorting and searching algorithms with apply in mechanical engineering. Hanoi towers. Quick sorting and searching. Big numbers. Polygon triangulation. Flag problem. Optimal and suboptimal salesman problem. N-Queens problem. Stable marriage problem.

practical teaching

Workshops with basic examples.

prerequisite

Knowledge of C/C++ languages. Basic knowledge of program design methodology. Fundamentals of software engineering.

learning resources

The necessary software is under the GNU license - free of charge. In LINUX, C/C++ is immediately available. If you use another operating system, C/C++ compiler can be downloaded from the appropriate Web site (see URL).

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 20

active teaching (practical)

auditory exercises: 6
laboratory exercises: 13
calculation tasks: 0
seminar works: 15
project design: 3
consultations: 0
discussion and workshop: 3
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 3
check and assessment of projects: 3
colloquium, with assessment: 0
test, with assessment: 4
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 35
laboratory exercises: 0
calculation tasks: 0
seminar works: 15
project design: 15
final exam: 30
requirements to take the exam (number of points): 35

references

Basics of operating systems

ID: MSc-0396
teaching professor: Радојевић Љ. Слободан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: project design
parent department: information technologies

goals

• Possess basic skills in the preparation of projects related to software development are important for small and medium-sized companies.
• Using some simple CASE tool for the design of some parts of the software.
• Acquisition of skills which bridges the barriers to collaboration teams to write and implement software.

learning outcomes

After successful completion of the program provided for in this case the student can:
• to recognize the organizational structure of the operating system,
• to understand the problems that arise in the operation and maintenance of operating systems,
• make a list of special operating system that is characterized by a complex machine.

theoretical teaching

The definition of operating system functions and structure of operating systems. Interfaces. Management functions of operating systems. Classification. The concept of process, multiprogramiranja. Core.
About memory allocation memory. Overlap and exchange. The protection zone of memory. Static and dynamic allocation. Fragmentation and Relocation of memory.
Organization of memory paging memory addresses. Results and memory blocks. Evidence of free blocks. Buffers mapping. Protection by means of keys, registry keys and memory keys. Sectional and segmental organization of memory paging tables segments. Evidence of free zones and their dynamic expansion. Joint use of free zones.
About virtual memory
Virtulna memory and its address space. Dynamic pages and reading segments. Replacement pages and physical memory segments.
The processes of a process definition. Operations processes.
The processes of two queues. The context of the process. The functions of the core management processes.
The three processes and problems synchronizing traffic lights.
The four processes of manufacturers and consumers of the process. Messages. SEND and RECEIVE operations of the processes. A modern operating systems comparison and analysis of some features of contemporary operating systems.

practical teaching

It consists of laboratory exercises that accompany the course, and continuous monitoring of the project through the creation of the final four seminars.

prerequisite

Preferred: Database Design, Software Engineering; essential: programming language C.

learning resources

- The necessary software for this case under the GNU license - free of charge.
- To run the necessary software is enough to have the simplest PC.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 20

active teaching (practical)

auditory exercises: 0
laboratory exercises: 25
calculation tasks: 0
seminar works: 11
project design: 0
consultations: 0
discussion and workshop: 4
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 9
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 1
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 5
laboratory exercises: 0
calculation tasks: 0
seminar works: 60
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

C/C++

ID: MSc-0508
teaching professor: Бенгин Ч. Александар
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: project design
parent department: information technologies

goals

• Introduce to C/C++; Structure of C/C++ and usability.
• Simple problems in mechanical engineering using C/C++.
• Art of pointers.
• Saving acquisition data in files, use that files and discussion results.

learning outcomes

After successful completion of the program provided for in this case the student can:
• Programing simple programs in C/C++ to solve problems in mechanical engineering.
• Use basic patterns in C/C++.
• Use pointers and simple data structures.
• Solve simple mechanical engineering problems with acquisition data in files.

theoretical teaching

Basic types. Constants. Operators and priority of operators. Blocks. If statement. Cycles. GOTO, BREAK and EXIT statements. Domain rules and variable declaration. Statical and registar variables. Definition and declaration of functions. Initialisation and recursion. Structures and fields. CHAR and Strings. Basic facts about pointers. Arrays and pointers. Adress aritmetic based on pointers. Command line arguments. Pointers to functions. Standard streams. Files and buffers. Some rules in using memory.

practical teaching

Workshops with basic examples in C/C++.

prerequisite

Knowledge of Programming, Computer tools, Numerical methods, Mathematics 1, Mathematics 2.

learning resources

The necessary software for this case under the GNU license - free of charge. If necessary use the Linux C/C++ is available to you immediately. If you use another operating system, C/C++ can be downloaded from the appropriate Web site (see URL) or the URL. To run the software necessary to possess enough simplest PC.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 20

active teaching (practical)

auditory exercises: 8
laboratory exercises: 17
calculation tasks: 0
seminar works: 8
project design: 4
consultations: 0
discussion and workshop: 3
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 4
check and assessment of projects: 4
colloquium, with assessment: 0
test, with assessment: 2
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 35
laboratory exercises: 0
calculation tasks: 0
seminar works: 30
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

Computer Networks

ID: MSc-0528
teaching professor: Митровић Б. Часлав
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: project design
parent department: information technologies

goals

Course objective:
• Introduction to the concept, standard tasks and operation of computer networks.
• Introduction to the protocol and other factors that control, manage and participate in creating a variety of processes and resources of computer networks and computers.

learning outcomes

The acquired knowledge allows students:
• to identify and suggest the type of computer network,
• to understand the problems that arise whendesigning computer networks,
• to create a project of computer network that includes a sugestion purchase of necessary equipment.

theoretical teaching

The basics of networking. The basic components of computer networks. Hardware. Software. The reasons for networking. The network environment.Use of Information. Passive network equipment. The active network equipment.Protocols. Computer interfaces. Standard computer networks. The division of computer networks. Grouping according to the capacity of computer networks for the transmission of data, the speed of transmission, according to a hierarchical or geographic area, according to the topology or logical and physical layout of nodes, as compared to nodes in a network, the architecture of computer networks and the access to computer networks.
The complexity and reference models.The role of the layers. OSI reference model. TSP / IP. Physical layer. USB, FireWire, IrDA, Bluetooth, Ethernet, WiFi, ISDN, xDLS. Link layer. The division of link layer. Access Control (MAC), Logical Link Control (LLC). Flow control. Control error. Link layer protocols. Ethernet. ARP.Token Ring. FDDI.
Network layer. Internet Protocol (IP).Networks and network classes. CIDR. ICMP.IGMP.IPX. RARP. BOOTP. DHCP. IPv6.
Transport layer. TCP, UDP, SCTP, SPX, iSCSI.
Application layer. SSH. Remote Desktop. DNS. FTP. Electronic mail. SMB / CIFS. HTTP. NTP. SNMP.Voice over IP. Instant Meassaging. Video conference.
Operating systems in computer networks. Implementation of network support. Comparison and analysis of some features of contemporary operating systems.
Security. Accessibility. Performance. Possible attacks and protect computer networks. Firewall. IDS and IPS systems.

practical teaching

It consists of auditory, laboratory exercises thatfollow the content of course

prerequisite

Required: Basic computer culture based on the use of a PC, regardless of operating sistema.WEB design in mechanical engineering,Software Engineering.

learning resources

The necessary software for this case under the GNU license - free of charge.
• To run the necessary software is enough to havethe simplest PC.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 20

active teaching (practical)

auditory exercises: 6
laboratory exercises: 21
calculation tasks: 0
seminar works: 7
project design: 3
consultations: 0
discussion and workshop: 3
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 7
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 3
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 15
laboratory exercises: 0
calculation tasks: 0
seminar works: 30
project design: 20
final exam: 30
requirements to take the exam (number of points): 35

references

Designing software for mechanical engineers

ID: MSc-0605
teaching professor: Радојевић Љ. Слободан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: information technologies

goals

• Prepare inputs for the engineering software based on standard calculations.
• Preparation of engineering calculations for effective programming and obtain efficient programs.
• Testing and verification of software engineering. Validation of software engineering.
• Use SQL to get information from databases.
• Use SQL for engineering decision making.
• Organization, normalization of data in the database.
• Privacy, data archiving. Issues of software licensing.

learning outcomes

After successful completion of the program provided for in this case the student can:
• Prepare a budget for programming.
• to assess the quality of information obtained from the input data that are processed program written for a defined budget.
• use the database for specific problems in mechanical engineering.
• use SQL as a generator of low-level information for software engineering.

theoretical teaching

1. Basic numerical methods in the calculations.
2. Designing software for selected numerical methods and calculations. Finding the zero function. Numerical differentiation and numerical integration.
3. Designing software for selected numerical methods and calculations. Numerical solution of partial differential equations and first order. Basic statistics.
4. Relational algebra, relations, and indexing. Basic SQL commands to create objects.
5. Basic SQL commands to update the object and relational operations.
7. Testing program. Validation of results and errors in calculation.
8. Software Licensing.

practical teaching

It consists of the auditory, laboratory exercises that accompany the course.
Case Studies. The commemoration of the database design, different tools.
Database-based storage of drawings, photographs and complex objects.

prerequisite

Database design. Software Engineering.C/C++

learning resources

The necessary software for this case under the GNU license - free of charge. If you use Linux you needed Python is readily available. If you use another operating system, Python can be downloaded from the appropriate Web site (see URL) or the URL. To run the software necessary to possess enough simplest PC.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 20

active teaching (practical)

auditory exercises: 11
laboratory exercises: 19
calculation tasks: 0
seminar works: 5
project design: 2
consultations: 0
discussion and workshop: 3
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 7
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 3
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 35
laboratory exercises: 0
calculation tasks: 0
seminar works: 30
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

Jery R. Hanly, Essential C++ for Engineers and Scientists, Addison Wesley, ISBN 0-201-74125-3

Digital system design

ID: MSc-0597
teaching professor: Бучевац М. Зоран
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: information technologies

goals

•Introducing with: number systems, Boolean algebra and binary logic, logic functions as well mastery of their usage and manipulation.
• Mastering of: various types of logic circuits-LC and methods for their analysis and design.
• Mastering of handling with integrated digital circuits and oscilloscope.

learning outcomes

• Proper understanding of the nature of digital computers and processes inside them.
• Manipulating digital computers in hardware and software sense as a part of a digital control systems (DCS).
• Using the methods of analysis and synthesis of LC.
• Solving of computational nature problems related to the analysis and synthesis of LC, in "off line" mode, by means of digital computers.
• Analysis and design of real physical LC.

theoretical teaching

•Number systems: definitions; conversion; arithmetic; complements; codes
•Boolean algebra and binary logic: definitions
•Logic functions: definition, logic digrams, minimizing
•Combinational logic circuits: definition, design; arithmetic LC; code converters; analysis
•Combinational logic circuits with integrated logic circuits: design; adders; magnitude comparator; decoder and demultiplexer; coder and multiplexer; ROM and programmable logic array
•Synchronous sequential logic circuits: concept; flip flops; analysis; design
•Asynchronous sequential logic circuits: analysis and design
•Registers, counters and memory units
•Algorithmic sequential logic circuits: flow chart; synchronization; design of control block
•A/D and D/A converters: conversion procedures

practical teaching

PA
Examples:
•number systems; arithmetic operations
•Boolean algebra theorems
•minimizing by map and tabulation methods
•design and analysis of combinational LC
•analysis and design of synchronous sequential LC
•analysis and design of asynchronous sequential LC
•design of counters, algorithmic sequential LC
•various types of A/D and D/A converters

PL

•Simulation of binary numbers and BCD code
•Physical interpretation of logical operations
•Logic gates
•Combinational LC; code converters
•Design with digital multiplexers
•Flip flops; synchronous and asynchronous sequential LC
•Counters, registers; memory unit; algorithmic sequential LC
•A/D and D/A converters

PZ
•Logic functions and gates, conventional and integrated combinational LC
•Design of synchronous and asynchronous sequential LC

prerequisite

• Basic knowledge of undergraduate calculus.
• Basic knowledge of undergraduate electrotechnics.

learning resources

1.Manuscript at http://au.mas.bg.ac.rs/Nastava-Kau/Nastava_Download.htm, DVL
2.Zoran Bučevac: Laboratory exercises for digital systems, Mechanical engineering faculty, Belgrade 2011, PRA, library and bookstore of MEFB
3.Power supply, oscilloscope, lab. for Digital systems, EOP/LEO
4.Protoboards, integrated circuits, Lab. for Digital systems, EOP/LEO
5.Freeware software, MEFB
6.PCs, Lab. for Digital systems and Computer lab. MEFB

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 12
laboratory exercises: 15
calculation tasks: 3
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 3
check and assessment of lab reports: 1
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 5
test, with assessment: 1
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 35
laboratory exercises: 5
calculation tasks: 25
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 0

references

M. Morris Mano, Digital design, Prentice-Hall, New Jersey, 1984., KSJ, available in library of MEFB
A. D. Friedman, Fundamentals of logic design and switching, Computer Science Press Inc., Rockville, Maryland, 1986., KCJ
A. Paul Malvino, D. P. Leach, Digital principles and applications, McGraw-Hill, New York, 1975., KSJ, available in library of MEFB
K. L. Short, Microprocessors and programmed logic, Prentice-Hall, Englewood Cliffs, NJ, 1981., KCJ
J. B. Peatman, Digital hardware design, McGraw-Hill, N.Y., 1980, KCJ

Distributed Systems in Mechanical Engineering

ID: MSc-0522
teaching professor: Митровић Б. Часлав
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: project design
parent department: information technologies

goals

• Introduction to the paradigm of distributing data
• Knowledge of basic protocols for the transfer and sharing of distributed data.
• Designing local area networks based on different technologies
• Introduction to multiprocessor distributed systems in the automotive and aircraft industry
• Introduction to algorithms that are typical of multi-processor distributed systems

learning outcomes

Стечено знање омогућава студенту:

• to recognize the conditions for the formation of local area networks
• to allocate names to resources on the net
• to control and menage assigned resources
• to understand the multi-processor and redistribution of data among them

theoretical teaching

Local and remote computer network as a weak coupled systems. The concept of server and service provider
Indoor network systems. Assignment of rights and names in the closed network systems. Application of these systems in the automotive and aircraft industry.
Local area network-LAN
Connect local area networks. The protocols in use. Bluetooth protocol for small local networks. Routing and ranges in routing.
Recommendations in the formation of IEEE local computer networks and their links.
IP protocol.
Wireless local area networks. Use of multi-radio waves in the small computer networks. User control in a wireless network
Multiprocessor systems. Algorithms for controlling the resources used in operating systems for multiprocessor hardware systems.
The case studies specific to the automotive industry. Case studies characteristic of the civil and military aerospace industry.

practical teaching

It consists of auditory, laboratory exercises that accompany the course. We should particularly look at case studies in the auto industry and the aviation industry.

prerequisite

learning resources

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 20

active teaching (practical)

auditory exercises: 6
laboratory exercises: 16
calculation tasks: 0
seminar works: 7
project design: 8
consultations: 0
discussion and workshop: 3
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 2
check and assessment of projects: 5
colloquium, with assessment: 0
test, with assessment: 3
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 15
laboratory exercises: 5
calculation tasks: 0
seminar works: 15
project design: 30
final exam: 30
requirements to take the exam (number of points): 35

references

Information integration of business functions 2

ID: MSc-0608
teaching professor: Митровић Б. Часлав
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: information technologies

goals

• Design and management of digital integrated business companies / factory, according to the business performance of integrated company,
• Acquiring knowledge, skills and competencies of the information and functional integration of the company,
• Integration of engineering, production and business activities
• Learn about the business performance of integrated company,
• Training to use commercial software for production management,
• Implementation of new information and communication technologies.

learning outcomes

The acquired knowledge to the student:
• Understand the operation of an integrated business enterprise / factory,
• Applies new information and communication technology,
• Critically observe production systems and business processes,
• Plans computerized activities, processes and systems,
• Approves new methods of learning and design,
• Develop cognitive traits of creative engineers in computer science,
• Participates in project teams of students and experts
• Is able to conduct business discussions with business partners.

theoretical teaching

Lesson 1
• Model information and functional integration of the company.
• Model reference CIMOS ESPRIT's open architecture information and communication systems.

Lesson 2
• The cybernetic definition of business systems, business processes and business domains.
• The pace and complexity of business systems and processes.

Lesson 3
• CIMOS functional entities and the transfer of information across levels of business.
• Enterprise activities, functional operations and business events.
• Integration of engineering, production and business activities.

Lesson 4
• Modeling for enterprise integration and a digital description of the business.
• Modeling of educational and business environment is an integrated enterprise.
• Functional analysis of systems and processes with the requirements for the synthesis of new designs.

Lesson 3

• Design of technical systems, products and technologies.
• The documentation and electronic exchange of information.

Lesson 6
• planning, (re) scheduling and execution of business operations.
• Optimal flow through the business sectors and facilities.
• Management and storage of materials throughout.

Lesson 7
• Information flow and integrated business tools.
• Reliability and track products through the life cycle.
• The software and integrated systems management company.

Lesson 8
• An integrated system of quality assurance.
• Procedures for quality.
• Quality standards.
• Integrated management levels (informational, operational, business, strategic).

Lesson 9
• Technology innovation in business.
• Cost management.
• Information and communication infrastructure is an integrated enterprise.
• Virtual Enterprise.

Lesson 10
• Business performance intelligent digital business enterprises.
• Business planning and development of competitive enterprises in the world market of goods, capital and knowledge.
• Software production management.
• Analysis of the results (outcomes) of learning objects.
• Preparation and instructions for the exam.

practical teaching

It consists of the auditory, laboratory exercises that accompany the course.
• Information integration of production and business enterprises.
• Systems for managing computer-integrated company activities.
• Business profile production companies.
• Information and functional integration of business enterprises.
• Students carry out professional training in an industry of Serbia or the professional excursion abroad.

prerequisite

Attended and passed the course at undergraduate level: Information integration of business functions or taking an entrance test.

learning resources

• Students are available to licensed software owned by the faculty.
• Students are available freeware software.
• Student must have a PC simplest configuration.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 20

active teaching (practical)

auditory exercises: 2
laboratory exercises: 8
calculation tasks: 6
seminar works: 8
project design: 10
consultations: 4
discussion and workshop: 2
research: 0

knowledge checks

check and assessment of calculation tasks: 1
check and assessment of lab reports: 1
check and assessment of seminar works: 2
check and assessment of projects: 2
colloquium, with assessment: 2
test, with assessment: 2
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 15
laboratory exercises: 10
calculation tasks: 10
seminar works: 10
project design: 15
final exam: 35
requirements to take the exam (number of points): 35

references

Spasic, Ž., Information integration of business functions, Book, Mechanical Engineering, Belgrade
Spasic, Ž., Integrated digital quality universities, Monograph, Faculty of Mechanical Engineering, Belgrade, 2007.
Spasic, Ž. Nedeljkovic, M., Bosnjak, S. Obradovic, A., University of Belgrade - Mission to the European integration process, Monograph, Faculty of Mechanical Engineering, Belgrade, 2003.
Faculty of Mechanical Engineering: Mechanical Engineering Alumni Fund - αMEβ, Editors Ž. Spasic and M. Nedeljkovic, B. Rosic, Č. Mitrovic, Releases Second Alumni Congress, Belgrade, 2007.

Information Technology Projects Evaluation

ID: MSc-0512
teaching professor: Дондур Ј. Никола
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: information technologies

goals

Understanding of the importance of the planning process, assessment and evaluation of projects in the field of information technologies. Getting to know different methodological approaches for analysis of IT/IS projects. Learning the sophisticated techniques of financial and economic analysis, as well as standard techniques for management of IT/IS projects. Learning the techniques and routines for identification and monetary quantification of hardly visible costs and effects implied in the implementation of IT/IS projects.

learning outcomes

After having attended the module, the student should be able to: identify the project idea, prepare a database with all costs and effects of IT/IS projects, calculate criteria for selection of project alternatives, acquire knowledge and practices for recognition of hardly visible costs and effects of IT/IS projects, organise networks of activities, flows of project resources with choice of optimal paths and minimum costs and assess uncertainty and risk of IT/IS projects.

theoretical teaching

Projects in the area of information technologies, planning and assessment of IT/IS projects, methods of assessment and evaluation of IT/IS projects, standard (classical) methods of commercial assessment of IT projects, standard methods of economic assessment of IT projects, possible application of standard methods on IT/IS projects - COMFAR,COSTTAB, quantification of financial and economic net effects of IT/IS projects, analysis of uncertainty and risks in planning – use of software packages RISK, RISKVIEW, BESTFIT, CRYSTAL BALL, assessment and evaluation of IT/IS projects, management of IT/IS projects – use of software packages MSPROJECT, PRIMAVERA

practical teaching

Practical teaching consists of auditory and laboratory exercises as integral part of the module content. Auditory exercises include simple demonstrations of theoretical materials presented through examples and accompanied by the explanations to each step in the procedure of IT/IS project evaluation. In laboratory exercises, by using appropriate software packages, real examples of assessment, evaluation and management of IT/IS projects are prepared.

prerequisite

Required: Basic knowledge of computer science, economics and statistics. Preferred: attended modules on Databases, WEB Design.

learning resources

Softwares: EXCEL, MSPROJECT, RISKPROJECT, RISKFOREXCEL. Books: Economic Project Analysis, Information Technology Evaluation Methods and Management,

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 20

active teaching (practical)

auditory exercises: 9
laboratory exercises: 15
calculation tasks: 0
seminar works: 16
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 1
check and assessment of lab reports: 1
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 4
test, with assessment: 4
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 55
laboratory exercises: 5
calculation tasks: 5
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

David Potts:Project Planning and Analysis for Development,Rienner, London, 2002.

Introduction to engineering simulations

ID: MSc-0474
teaching professor: Петровић И. Златко
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: project design
parent department: information technologies

goals

Introduces to students engineering numerical simulations on continuous media. Understanding of physical laws, boundary and initial conditions. Uniqueness of solution and well posed problems. Recognition of type of PDEs and their influence on additional conditions. How type of approximation depends on type of PDEs. Develop ability to develop simulation code to solve model PDEs.

learning outcomes

After completion of this course student is able to recognize type of the problem, and to apply sufficiently additional conditions to get unique solution of engineering problem. Recognize basic finite difference schemes for approximation of typical model partial differential equations. Improve basic programing skills to simulate simple engineering problems. Recognize software structure used to solve engineering problems.

theoretical teaching

1. Introduction to engineering simulations, types of PDEs, approximation of PDEs by finite differences, order and accuracy of approximations.
2. Approximation of PDES and corresponding boundary conditions.
3. Solution of model parabolic partial differential equations.
4. Solution of model elliptic partial differential equations. Speed of convergence.
5. Solution of model hyperbolic partial differential equations.
6. Stability and convergence of finite difference approximations.
7. Solution of Burgers Equation.
8. Conjugate gradient method.
9. Multigrid method.
10. Introduction to supercomputing.
11. Message passing interface.

practical teaching

Exercises are consisted of three parts: (1) Introduction to work on Linux cluster. Elements of operating system. Compilation and execution of programs in parallel environment. Graphical tools for presentation of results. (2) Recitations where lectures are additionally exercised and explained. (3) Computer exercises where students key in programs and simulate problems. It is also required that students present results in acceptable form.

prerequisite

No prerequisites.

learning resources

1. Linux cluster

2. GnuPlot, Octave, ..
3. Overhead projector.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 0
laboratory exercises: 20
calculation tasks: 0
seminar works: 5
project design: 0
consultations: 5
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 10
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 15
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 55
project design: 0
final exam: 30
requirements to take the exam (number of points): 25

references

Lecture slides

Object oriented paradigm

ID: MSc-0527
teaching professor: Радојевић Љ. Слободан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: project design
parent department: information technologies

goals

• Introduction to OOP paradigm.
• Purposeful use of classes, objects, inheritance, encapsulates, methods and hiding.
• Basic knowledge of classes, derived classes, methods.
• Object-oriented methodology for designing data structures and applicable programs.
• Problems that are naturally solved using object-oriented design and programming methodology.

learning outcomes

With acquired knowledge student can:
• to recognize the conditions for using object-oriented design and programming methodology,
• to design simple user class and link them with the system classes,
• user to design simple methods and their use in system design methods,
• to use the programming languages C + + and Java.

theoretical teaching

Compilers, interpreters and machines. Weak and strong typed programming languages.
Object and class, relationship and real-life examples and techniques.
The natural definition of class, subclass, supclass. The term instance - the object.
Fundamentals of programming language C + +. The differences between the programming languages C and C + +.
Defining classes in C + +. Application of operations and creating objects.
Object-oriented design data, operations, and problems in the programming and implementation.
The life span of the object.
The basics of Java programming. The differences between the programming languages C + + and Java.
Defining the class and subclass supclass in programming languages C + + and Java.
Inheritance in C + + and Java, the advantages and disadvantages.
Overloading of operators and create threads and streamline, as well as specific structures in Java.
Problem encapsulate objects and classes. The advantages and disadvantages.

practical teaching

It consists of auditory, laboratory exercises that accompany the course.
The commemoration of the programming language PHP programming.
Basic examples of the programming language C + + and Java.

prerequisite

With the knowledge C language. Basic knowledge of design methodology. Fundamentals of software engineering.

learning resources

The necessary software for this case under the GNU license - free of charge. If necessary use a Linux C + + and JAVA will immediately available. If you use another operating system C + + can be downloaded from the appropriate Web site (see URL) or the URL. To run the software necessary to possess enough simplest PC.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 20

active teaching (practical)

auditory exercises: 11
laboratory exercises: 19
calculation tasks: 0
seminar works: 5
project design: 2
consultations: 0
discussion and workshop: 3
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 7
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 3
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 35
laboratory exercises: 0
calculation tasks: 0
seminar works: 30
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

Professional Practice M - MIT

ID: MSc-0382
teaching professor: Митровић Б. Часлав
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 1
final exam: project design
parent department: information technologies

goals

To provide students with practical experience of staying in an environment in which the student will realize his future career. Identifying the basic functions
information system in the field of design, development and production software, as well as roles and tasks of mechanical engineering of information technology in such
business system.

learning outcomes

Training students to apply previously acquired theoretical and practical engineering and scientific knowledge of information technology to solve specific
practical engineering problems in the selected companies or Institutions. Activities to introduce students to selected companies or institutions,
way of doing business, management and the place and role of IT engineers in their organizational structures.

theoretical teaching

MIT provides students with practical training by working with reputable companies and scientific research institutions of Serbia in the IT sector.
Practical form for each candidate separately, in agreement with the management companies or research institutions in which
pursuing their profession, and in accordance with the development of new information technologies from which the student has previously acquired theoretical knowledge.

practical teaching

Practical work consists of student involvement in the process of the enterprise or research institutions, consulting and writing diary
professional practice in which a student describes the activities and operations that is performed during the professional practice

prerequisite

Required: Basic IT knowledge. Prior knowledge acquired in previous modules MIT cources listened.

learning resources

Lectures for MIT courses modules that can be downloaded from the FTP server module MIT: ftp://mit.mas.bg.ac.rs

number of hours

total number of hours: 46

active teaching (theoretical)

lectures: 0

active teaching (practical)

auditory exercises: 0
laboratory exercises: 42
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 0
final exam: 4

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 0
laboratory exercises: 80
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 10
requirements to take the exam (number of points): 35

references

Programmable Control System

ID: MSc-0190
teaching professor: Пилиповић Д. Мирослав
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: information technologies

goals

Acquisition of knowledge about the application, design, programming and introduction of programmable control systems into industry and contemporary manufacturing. Skill development for solving practical control problems in idustry by using computer, information and control technologies and adequate scientific methods.

learning outcomes

The student should:
1. Uderstand the principles, place and role of the programmable control systems in industry and programmable automation, link knowledge of related subjects to apply it in programmable automation;
2. Master scientific methods of analysis, synthesis, design and introduction of programmable control systems in programmable automation;
3. Know practical problem-solving and how to apply computer technology and contemporary programmable control systems.

theoretical teaching

1.Programmable and computer control systems in automation. CNC, robot controllers, programmable controllers, programmable automation controllers and computers.
2. Switching algebra. Logical functions, theorems and normal forms.
3. Technologies and components. Sensors, actuators, logic and memory elements.
4. Combination and sequential automata. Definitions, mathematical models, analysis and synthesis.
5. Programmable controllers. Functions, hardware, software, input/output modules. Programming languages and programming techniques according to the IEC 61131 standard.
6. CNC control. Functions, hardware, software, mathematical models. Main and auxiliary movement control, interpolation and internal calculations. Control panel, man-machine interface, programming according ISO 6983 and ISO 14649 (STEP-NC).
7. Open-architecture programmable control systems.
8. Distributed control systems and IEC 61499.
9. Examples of the modern programmable control systems and tehir application.

practical teaching

1.Auditorial exercises: Tasks in exemplified programmable control systems design, analysis and synthesis, with programming and control scheme design.
2. Laboratory exercises: exemplified programmablle control systems design, with analysis and synthesis and practical realization of the example in laboratory conditions by applying electro-pneumatic, electrical and electronic components, modular robots and control systems based on computer, CNC, robot controllers and programmable controllers with programming.
3. Seminar work: exemplified programmablle control systems application, with analysis and synthesis, programming and control scheme design.

prerequisite

Defined by curriculum of study program.

learning resources

1. Pilipović, M. Programmable control systems - Handouts, FME, Belgrade, 2011, DVL
2. Pilipović M., Manufacturing processes automation: Laboratory, FME, Belgrade, 2006, PRA. /In Serbian/
3. Lab desk with, electro-pneumatic and electric components and programmable controllers, Lab for manufacturing automation, EOP/LRS.
4. "Pick and Place" electro-pneumatic modular robots with programmable controllers, Lab for manufacturing automation, EOP/LPI.
5. Programming computers, Lab for manufacturing automation, IKT/PPC.
6. Software for programmable controller programming, Lab for manufacturing automation, IKT/RRO.
7. Communication network of computers and programmable controllers, Lab for manufacturing automation, IKT/KIO.
8. CNC and robot controllers, Lab for machine tools, EOP/LPI

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 10
laboratory exercises: 12
calculation tasks: 0
seminar works: 6
project design: 0
consultations: 2
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 4
check and assessment of seminar works: 2
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 4
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 20
laboratory exercises: 20
calculation tasks: 0
seminar works: 15

project design: 0
final exam: 40
requirements to take the exam (number of points): 36

references

Kandray, D., Programmable Automation Technology - An Introduction to CNC, Robotics and PLC, Industrial Press, 2010.
Michael Sava, Joseph Pusztai, Computer Numerical Control Programming, Prentice Hall, Inc., 1990.
Parr, E., Programmables Controllers An Engineers Guide, Elsevier 2003.
Informatika: INFO 73 Programmable Controllers, Programming Guide, Informatika, Belgrade, 2011. /In Serbian/
GE-Fanuc, CNC 0M, Programming and Operation Manual, GE-Fanuc, 1995.

SQL

ID: MSc-0394
teaching professor: Радојевић Љ. Слободан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: project design
parent department: information technologies

goals

• Understanding of obtaining and storing information from basic data.
• Usage SQL for getting information from databases.
• SQL as the basis of each program for database management.
• Organization and normalization of data in the database.
• Complexity and Redundant data in the database.
• Protection and data archiving.

learning outcomes

After successful completion of the program provided for in this case the student can:
• Use SQL to create, maintain, search of database,
• Apply SQL in mechanical engineering,
• Apply procedures for protecting and archiving databases.

theoretical teaching

1. Object and relational database model.
2. Physical and logical database model.
3. Relational algebra, relations, and indexing.
4. Basic SQL commands to create objects.
5. Basic SQL commands to update the objests.
6. Basic SQL commands for relational operations.
7. Normal forms.
8. Distributing data.

practical teaching

It consists of auditory, laboratory exercises that accompany the objects.
Reminder of the database design with different tools.
Common examples of databases that characterize the modern mechanical engineering.
Database-based storage for drawings, photographs and complex objects.

prerequisite

Database design. Software Engineering.C/C++

learning resources

The necessary software for this course under the GNU license - free of charge. If you use Linux your MySQL client needed is readily available. If you use another operating system you can download the MySQL client with the appropriate Web site (see URL) or the URL. To run the software necessary to possess enough simplest PC.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 20

active teaching (practical)

auditory exercises: 11
laboratory exercises: 19
calculation tasks: 0
seminar works: 5
project design: 2
consultations: 0
discussion and workshop: 3
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 7
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 3
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 35
laboratory exercises: 0
calculation tasks: 0
seminar works: 30
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

Statistical analysis in mechanical engineering

ID: MSc-0503
teaching professor: Вељковић А. Зорица
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: information technologies

goals

Goals of the course are introduction of basic and up-to date statistical methods for engineering practice. Main goals of the course is identification of problems, methods for their solving, defying problem solving procedures and systems for decision making, based on obtained results, i.e. interpretation of numerical results for use in practice. Analyses of large sets of data are especially emphases.

learning outcomes

After successfully completed course, students obtained knowledge of statistical methods and their use for solving specific problems in practice. They should be able to define the problem, identify and apply adequate statistical procedures and obtain competent answers. During the course students master the procedures for use of adequate statistical methods. It is expected that students could be able for interpretation of statistical results for their practical usage. Also it is expected that students can use and work in available statistical software.

theoretical teaching

Course include following subjects: Basic definitions and descriptive statistics; Discrete and continuous probability distributions for random variables, their characteristics, statistics and moment generating functions. This part include distributions such as uniform, binomial, Poison, normal, log-normal, weibul, gamma, beta, exponential etc; Tests of hypothesis is divided on parameter and nonparametric testing. Parameter testing includes one and two sample tests for means, proportion and variance. Nonparametric testing include goodness of fit by Kolmogorov test, comparison tests for distributions such as Mann Whitney test, Kolmogorov-Smirnov test, sign test, Darling Anderson test, Wilcoxon tests for median; Simple linear and multiple regression and correlation for large data using matrix approach, model building, testing of adequacy of the models, and forecasting. Problems for nonlinear regression are solved by use of multiple regression and orthogonal polynoms; One-way and two-way analysis of variance, followed by design of experiments, i.e. full and fractional factorial design and Taguchi's approach.

practical teaching

Exercises follow the contents of lectures by examples and problem solving in available statistical software.

prerequisite

No conditions, it is preferable to have knowledge from other MIT courses.

learning resources

http://mit.mas.bg.ac.rs

All materials for successful following of the course - handouts, materials for exercises and projects are available to students before lectures in electronic form.(in Serbian)

Radojević S, Veljković Z, Kvantitativne metode, CD. MF (in Serbian)

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 20

active teaching (practical)

auditory exercises: 15
laboratory exercises: 15
calculation tasks: 10
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 3
check and assessment of lab reports: 4
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 6
test, with assessment: 0
final exam: 2

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 50
laboratory exercises: 0
calculation tasks: 15
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 31

references

Radojević S, Veljković Z, Kvantitativne metode, CD. MF
Montgomery, DC, Runger, GC Applied Statistics and Probability for Engineers, Fourth Edition, Wiley, 2007

The Data Exquisite in Mechanical Engineering

ID: MSc-0510
teaching professor: Митровић Б. Часлав
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: information technologies

goals

Course objective:

• Numerical and mathematical analysis capabilities for each measurement.
• Design and write programs for analyzing measurements.
• Comparison analysis of numerical data processing and analysis software.
• Implementation of PHP and JAVA Script.

learning outcomes

The acquired knowledge allows:

• That be entered professional do the measurements and determine the necessary and forward the required size,
• That the measurement is so mathematical, numerical and statistical analysis and then to be graphical and logical preparation for further analysis,
• That, using PHP or Java Script, or both, make software to perform accurate data processing which is a pre-determined mathematically.

theoretical teaching

BASIC THEORY OF SAMPLES. Population and simple sample with replacement and without returning. Sampling - the empirical distribution as a possible Code of Conduct of the population.

TREATMENT OF STATISTICAL BASIS
The concept of statistical meetings. Mean values of statistical assemblage. Dispersion. Models of the distribution. The trend in the study of statistics. Time series in the study of statistics. Statistical indicators in the study. Hypotheses and tests.

ARISING FROM PROBABILITY. The mathematical probability of an event. Addition theorem of probability. Multiplication theorem of probability. Permutations, combinations and variations of elements of one set.

REPETITORIA numerical methods. Some algebraic problems. Interpolation polynomials. Lagrange interpolation polynomials (Joseph-Louis Lagrange). Newton (Isaac Newton) interpolation polynomials. Numerical integration. Newton-Coates (Isaac Newton - Roger Cotes) formula. Simpson (Thomas Simpson) formula.

IMMEDIATE MEASUREMENT ACCURACY Equal and unequal. Determining the value of measured values. Determination of measurement error. Distribution law of random sizes.

INDIRECT MEASUREMENT ACCURACY OF EQUAL. Determining the average size of the errors of certain indirect measurement. Determining the size of the average error of certain indirect measurement of the same accuracy. The general case of indirect measurement of the system of equations equal accuracy.

INDIRECT MEASUREMENT ACCURACY unequal. Normal equations indirect measurements of unequal accuracy. Control in solving the normal equation of unequal accuracy.

CONDITIONAL MEASUREMENTS SIZE. The process of measuring the conditional correlations. The process of reducing the indirect measurements.
Basic Theory of Correlation. Two-dimensional distribution laws of random sizes.

practical teaching

It consists of auditory, laboratory exercises that accompany the course.

prerequisite

Required: Basic computer culture based on the use of a PC, regardless of operating sistema.Osnovno knowledge of mathematical logic.

learning resources

Audience is available licensed software owned by the faculty. Listeners freeware software is available.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 20

active teaching (practical)

auditory exercises: 6
laboratory exercises: 21
calculation tasks: 0
seminar works: 7
project design: 3
consultations: 0
discussion and workshop: 3
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 7
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 3
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 35

laboratory exercises: 0
calculation tasks: 0
seminar works: 30
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

Č. Mitrovic, S. Radojevic, The Data Exquisite in Mechanical Engineering, a textbook (in preparation) Faculty of Mechanical Engineering, Belgrade

Methods optimization

ID: MSc-0485
teaching professor: Росић Б. Божидар
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: information technologies

goals

The main goal of this course for the student is to give the necessary knowledge of:
• numerical analysis and optimization,
• understanding general principles of design optimization
• formulating the optimization problems and identify critical elements.

learning outcomes

During this course, the student will carry out:
• Overview of design optimization
• Fundamentals of engineering optimization
• Problem formulation
• strategies for optimization

theoretical teaching

1.Introduction to Modeling and Optimum Design Process. Optimum design problem formulation.
A general mathematical model for optimization.
2.Graphical Optimization.Identification of feasible region. Use of MATLAB for graphical optimization.
3. Unconstrained Optimum Design Problems. Optimality conditions for functions of several variables.
4. Constrained optimum design problems. Necessary conditions: equality constraints.
Necessary conditions: inequality constraints - Karush-Kuhn-Tucker (KKT) conditions.
Postoptimality analysis: physical meaning of Lagrange multipliers.
Engineering design examples with MATLAB.
5. Linear Programming. Problem definition. Standard LP format. Graphical solution.
Characteristics of the solution. Optimum solution for LP problems.
6. Numerical Solution - the Simplex Method.
Basic Steps of the Simplex Method. Simplex Algorithm. Solution using MATLAB's optimization toolbox.
7. Nonlinear Programming. Problem formulation. Graphical solutions. Equality constrained problem. Inequality constrained optimization.
Basic ideas and algorithms for step size determination.
8. Numerical methods - The One-dimensional Problem.
Newton-Raphson method.
Bisection method.
Polynomial Approximation.
Golden section method.
Optimum design examples with MATLAB.
9. Numerical Methods for Unconstrained Optimization.
Numerical Methods - Nongradient methods.
Powell's method.
Numerical Methods-Gradient-Based Methods.

Conjugate Gradient (Fletcher-Reeves) Method.
Davidon-Fletcher- Powel (DFP) method.
10. Numerical Methods for Constrained optimization
Problem definition. Necessary conditions. Method of feasible directions.Gradient projection method.
Exterior penalty function method.
Optimum design examples with MATLAB.

practical teaching

Consists of the auditory and laboratory exercises.
Projects are main component of this course.

prerequisite

Knowledge of linear algebra and numerical mathematics. Computer programming in MATLAB.
Some knowledge of basic machine elements and mechanics.

learning resources

Computer Usage:
Students extensively use the computer and optimization toolbox using MATLAB program.
Handout.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 20

active teaching (practical)

auditory exercises: 6
laboratory exercises: 21
calculation tasks: 0
seminar works: 7
project design: 3
consultations: 0
discussion and workshop: 3
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 7
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 3
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 35
laboratory exercises: 0
calculation tasks: 0
seminar works: 30
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

Jasbir S. Arora " Introduction to Optimum Design", Elsevier Academic Press
P. Venkataraman " Applied Optimization with Matlab Programming" John Wiley and sons, inc.
H. Eschenauer, J. Koski, A. Osyczka "Multicriteria Design Optimization", Springer-Verlag

internal combustion engines

Computer based measurements
Computer Based Measurements
Diagnostic and Maintenance of IC Engines
Diagnostic and Maintenance of IC Engines
Digital data acquisition and virtual instrumenataion
Ecology of Mobile Power Sources
Ecology of Mobile Power Sources
Engine Design 1
Engineering Practice MSc - IC Engines
Engineering Practice MSc - IC Engines
Engine fuelling and ignition systems
IC ENGINES DESIGN 2
IC Engines Mechatronics
IC Engine Testing
IC Engine Testing
Internal combustion engines
Marine Engines
Marine Engines
Reciprocating Compressor
Reciprocating Compressors
Supercharging of IC Engines
Supercharging of IC Engines
Engine Design Project
Engine Design Project
Engine Working Processes

Computer based measurements

ID: MSc-0604
teaching professor: Цветић Р. Милош
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: internal combustion engines

goals

The aim of the course is to provide comprehensive insight into the digital acquisition systems (DAQ) and, mainly, their usage in the field of testing of systems covered in the Mechanical Engineering; To introduce students the world of virtual instrumentation and graphical programming environment (LabVIEW) which is dedicated to development of DAQ applications. To gain experience on functioning and using DAQ systems through numerous, real world, examples. To get closer acquaintance with the sensors, and digital acquisition software & hardware, in general, and methods of DACQ software developing and testing.

learning outcomes

Ability to integrate sensors and DAQ hardware in measurement chain in order to fulfill specific requirements in the field of mechanical engineering system testing & measurements. Ability to build and test software application (LabVIEW virtual instruments) for measurement and automation of various mechanical engineering systems. Practical knowledge in computer based measurements of fundamental engineering data

theoretical teaching

Architecture and basic principles of data acquisitions systems (DAQS); Definition and clarification of the fundamental terms in the field of measurement technique. Using FFT signal analysis; Fundamentals of signal filtering (Analog & Digital); Hardware components of the DAQ module –DAQ device; Basic principles of digital data acquisition; Temperature sensors and signal conditioning; Sensors of speed, force, acceleration and signal conditioning; Specific issues on digital input/output of DAQ devices; Counters and their usage for counting of discrete events and position measurement; Frequency/Period measurement of the digital signal by means of counters; Communications standards in measurement instrumentation (RS-232, RS-422/485, IEEE-488 (GPIB));

practical teaching

Introduction to the Virtual Instrumentation (VI) and LabVIEW development environment; Data flow in VI; Troubleshooting and Debugging Vis; Implementing a VI; Managing Hardware resources (Low and High-Level File I/O); Common Design Techniques and Patterns; Synchronization Techniques; Event Programming; Error Handling; Controlling the User Interface (VI Server Architecture; Control references); File I/O Techniques ; Improving an Existing VI; Creating and Distributing Applications; Student Project: Building a DAQ with given requirements;

*)National Instruments (NI) Labview courses “Core 1” & “Core 2” are incorporated in the theoretical and practical teaching of this course. This course is in compliance with the “LabVIEW Academia” program and therefore offers students all benefits stated in LabVIEW Academia agreement.

prerequisite

No particular requirements for attending this course

learning resources

Handouts: N. Miljić, Computer Based Measurements & Virtual Instrumentation
DACQs: National Instruments USB 6008, MyDAQ, PXI ,...
Graphical Development Environment: National Instruments LabView 2010 with modules and toolkits (LVA package)
Auxiliary platforms: Demo board for simulation of analog and digital signals; Universal Amplifying / Conditioning board for various sensors; Driver board for DC and step motors

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 18

active teaching (practical)

auditory exercises: 22
laboratory exercises: 19
calculation tasks: 0
seminar works: 0
project design: 3
consultations: 0
discussion and workshop: 1
research: 0

knowledge checks

check and assessment of calculation tasks: 4
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 3
colloquium, with assessment: 0
test, with assessment: 3
final exam: 2

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 45
laboratory exercises: 0
calculation tasks: 0
seminar works: 10
project design: 15
final exam: 30
requirements to take the exam (number of points): 42

references

Labview Core 1 & 2 Course Manual & Exercises, National Instruments
Robert Bishop: LabVIEW 2009 Student Edition, Prentice Hall, 2010, ISBN13- 9780132141291
Jim Kring : LabVIEW for Everyone: Graphical Programming Made Easy and Fun (3rd Edition) , Prentice Hall, 2006, ISBN-13: 978-0131856721
John Essick: Hands On Introduction to LabVIEW for Scientists and Engineers, Oxford University Press, USA, 2008, ISBN13- 9780195373950
Robert H. King:Introduction to Data Acquisition with LabVIEW,McGraw-Hill,2009,ISBN-13: 9780077299613

Computer Based Measurements

ID: MSc-0703
teaching professor: Томић В. Мирољуб
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: project design
parent department: internal combustion engines

goals

The aim of the course is to provide comprehensive insight into the digital acquisition systems (DAQ), measurment systems and, mainly, their usage in the field of testing of systems covered in the Mechanical Engineering; To introduce students the world of virtual instrumentation and graphical programming environment (LabVIEW) which is dedicated to development of DAQ applications. To gain experience on functioning and using DAQ systems through numerous, real world, examples. To get closer acquaintance with the sensors, and digital acquisition software & hardware, in general, and methods of DACQ software developing and testing.

learning outcomes

Ability to integrate sensors and DAQ hardware in measurement chain in order to fulfill specific requirements in the field of mechanical engineering system testing & measurements. Ability to build and test software application (LabVIEW virtual instruments) for measurement and automation of various mechanical engineering systems. Practical knowledge in computer based measurements of fundamental engineering data

theoretical teaching

Architecture and basic principles of data acquisitions systems (DAQS); Definition and clarification of the fundamental terms in the field of measurement technique. Using FFT signal analysis; Fundamentals of signal filtering (Analog & Digital); Hardware components of the DAQ module −DAQ device; Basic principles of digital data acquisition; Temperature sensors and signal conditioning; Sensors of speed, force, acceleration and signal conditioning; Specific issues on digital input/output of DAQ devices; Counters and their usage for counting of discrete events and position measurement; Frequency/Period measurement of the digital signal by means of counters; Communications standards in measurement instrumentation (RS-232, RS-422/485, IEEE-488 (GPIB));

practical teaching

Introduction to the Virtual Instrumentation (VI) and LabVIEW development environment; Data flow in VI; Troubleshooting and Debugging Vis; Implementing a VI; Managing Hardware resources (Low and High-Level File I/O); Common Design Techniques and Patterns; Synchronization Techniques; Event Programming; Error Handling; Controlling the User Interface (VI Server Architecture; Control references); File I/O Techniques ; Improving an Existing VI; Creating and Distributing Applications; Student Project: Building a DAQ with given requirements;

*)National Instruments (NI) Labview courses “Core 1” & “Core 2” are incorporated in the theoretical and practical teaching of this course. This course is in compliance with the “LabVIEW Academia” program and therefore offers students all benefits stated in LabVIEW Academia agreement.

prerequisite

No particular requirements for attending this course

learning resources

Handouts: N. Miljić, Computer Based Measurements & Virtual Instrumentation
DACQs: National Instruments USB 6008, MyDAQ, PXI ,...
Graphical Development Environment: National Instruments LabView 2010 with modules and toolkits (LVA package)
Auxiliary platforms: Demo board for simulation of analog and digital signals; Universal Amplifying / Conditioning board for various sensors; Driver board for DC and step motors

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 18

active teaching (practical)

auditory exercises: 22
laboratory exercises: 19
calculation tasks: 0
seminar works: 0
project design: 3
consultations: 0
discussion and workshop: 1
research: 0

knowledge checks

check and assessment of calculation tasks: 4
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 3
colloquium, with assessment: 0
test, with assessment: 3
final exam: 2

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 30
laboratory exercises: 0
calculation tasks: 0
seminar works: 10
project design: 10
final exam: 40
requirements to take the exam (number of points): 30

references

Labview Core 1 & 2 Course Manual & Exercises, National Instruments
Jim Kring : LabVIEW for Everyone: Graphical Programming Made Easy and Fun (3rd Edition) , Prentice Hall, 2006, ISBN-13: 978-0131856721
Robert Bishop: LabVIEW 2009 Student Edition, Prentice Hall, 2010, ISBN13- 9780132141291
John Essick: Hands On Introduction to LabVIEW for Scientists and Engineers, Oxford University Press, USA, 2008, ISBN13- 9780195373950
Robert H. King:Introduction to Data Acquisition with LabVIEW,McGraw-Hill,2009,ISBN-13: 9780077299613

Diagnostic and Maintenance of IC Engines

ID: MSc-0381
teaching professor: Цветић Р. Милош
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: internal combustion engines

goals

Practical application of statistical methods for analysis and predictions of engine failures. Expanding knowledge in the field of tribology through study of engine parts friction, wear and lubrication. Basics understanding of On-Board Diagnostic (OBD). Application of modern computer-based diagnostic methods. Gaining knowledge of engine repair processes, especially of major overhaul.

learning outcomes

Application of statistical methods for analysis of machine and devices failures. General structure and realization of machines and devices maintenance and overhaul processes. Ability to analyse and establish the cause of engine failure. Application of OBD procedures. Ability to organize and supervise engine maintenance and major overhaul processes.

theoretical teaching

Quality and durability of engines, operations quality and engine operational safety. Engine reliability and statistical methods of reliability analysis. Steady and unsteady engine operations. Fuel consumption. Engine parts and sub-assemblies wear characteristics. Engine technical diagnostic. On-Board diagnostic. Engine major overhaul, cost of overhaul. Influence of operational factors on engine reliability and wear. Operational characteristics, typical failures and maintenance processes of main engine parts, sub-assemblies and systems. Analysis of engine wear as a function of engine speed and load.

practical teaching

a) Classroom sessions: numerical examples. Preparation for laboratory sessions.
b) Laboratory sessions: 1. Influence of adjustable engine systems parameters on engine operation and characteristics (fuel consumption, exhaust emissions). 2. Review and analysis of typical engine parts and sub-assemblies failures and damages. 3. Visit of representative engine service shop.

prerequisite

Mandatory: passed exam Internal combustion engines fundamentals. For MSc studies - IC Engines module - passed exam Engine Working Processes.

learning resources

Trifunović, R: Engine operation, 1st part, Faculty of Mechanical Engineering, Belgrade, 1983. (in serbian). Handouts (PDF files). Instructions to carry out laboratory sessions (PDF files). Numerical examples (PDF files). Test beds for IC engines testing, measuring equipment and data acquisition software, Center for IC engines.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 8
laboratory exercises: 5
calculation tasks: 12
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 5
research: 0

knowledge checks

check and assessment of calculation tasks: 4
check and assessment of lab reports: 2
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 4
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 20
laboratory exercises: 15
calculation tasks: 20
seminar works: 0
project design: 0
final exam: 45
requirements to take the exam (number of points): 30

references

Greuter, E., Zima, S.: Motorschäden: Schäden an Verbrennungsmotoren und deren Ursachen, 2. Aufl., Vogel, Würzburg, 2000. ISBN 3-8023-1794-7. (in german)
Клюев, В. В. (ред.): Технические средства диагностирования, Машиностроение, Москва, 1989. ISBN 5-217-00637-4. (in russian)
Mollenhauer, K., Tschoeke, H. (ed.): Handbook of Diesel Engines. Springer-Verlag, Berlin, Heidelberg, 2010. ISBN 978-3-540-89082-9.
Challen, B., Baranescu, R. (ed.): Diesel Engine Reference Book, 2nd Ed., Butterworth-Heinemann, Woburn, 1999. ISBN 0 7506 2176 1.
Basshuysen, R. von, Schaefer, F.: Internal Combustion Engine Handbook, SAE, Warrendale, 2004. ISBN 0-7680-1139-6.

Diagnostic and Maintenance of IC Engines

ID: MSc-0702
teaching professor: Томић В. Миродуб
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: internal combustion engines

goals

Practical application of statistical methods for analysis and predictions of engine failures. Expanding knowledge in the field of tribology through study of engine parts friction, wear and lubrication. Basics understanding of On-Board Diagnostic (OBD). Application of modern computer-based diagnostic methods. Gaining knowledge of engine repair processes, especially of major overhaul.

learning outcomes

Application of statistical methods for analysis of machine and devices failures. General structure and realization of machines and devices maintenance and overhaul processes. Ability to analyse and establish the cause of engine failure. Application of OBD procedures. Ability to organize and supervise engine maintenance and major overhaul processes.

theoretical teaching

1.Quality and durability of engines, operations quality and engine operational safety.2.Engine reliability and statistical methods of reliability analysis. 3.Steady and unsteady engine operations. 4.Fuel consumption. 5.Engine parts and sub-assemblies wear characteristics. 6.Engine technical diagnostic. 7.On-Board diagnostic. 8.Engine major overhaul, cost of overhaul. 9.Influence of operational factors on engine reliability and wear. 10.Operational characteristics, typical failures and maintenance processes of main engine parts, sub-assemblies and systems. 11.Analysis of engine wear as a function of engine speed and load.

practical teaching

a) Classroom sessions: numerical examples. Preparation for laboratory sessions.
b) Laboratory sessions: 1. Influence of adjustable engine systems parameters on engine operation and characteristics (fuel consumption, exhaust emissions). 2. Review and analysis of typical engine parts and sub-assemblies failures and damages. 3. Visit of representative engine service shop.

prerequisite

No prerequisites required.

learning resources

Trifunović, R: Engine operation, 1st part, Faculty of Mechanical Engineering, Belgrade, 1983. (in serbian). Handouts (PDF files). Instructions to carry out laboratory sessions (PDF files). Numerical examples (PDF files). Test beds for IC engines testing, measuring equipment and data acquisition software, Center for IC engines.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 8
laboratory exercises: 5
calculation tasks: 12
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 5
research: 0

knowledge checks

check and assessment of calculation tasks: 4
check and assessment of lab reports: 2
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 4
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 25
laboratory exercises: 15
calculation tasks: 20
seminar works: 0
project design: 0
final exam: 40
requirements to take the exam (number of points): 30

references

Mollenhauer, K., Tschoeke, H. (ed.): Handbook of Diesel Engines. Springer-Verlag, Berlin, Heidelberg, 2010. ISBN 978-3-540-89082-9.
Challen, B., Baranescu, R. (ed.): Diesel Engine Reference Book, 2nd Ed., Butterworth-Heinemann, Woburn, 1999. ISBN 0 7506 2176 1.
Challen, B., Baranescu, R. (ed.): Diesel Engine Reference Book, 2nd Ed., Butterworth-Heinemann, Woburn, 1999. ISBN 0 7506 2176 1.
Basshuysen, R. von, Schaefer, F.: Internal Combustion Engine Handbook, SAE, Warrendale, 2004. ISBN 0-7680-1139-6.

Digital data acquisition and virtual instrumenataion

ID: MSc-0498
teaching professor: Цветић Р. Милош
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: internal combustion engines

goals

The aim of the course is to provide comprehensive insight into the digital acquisition systems (DAQ) and, mainly, their usage in the field of testing of systems covered in the Mechanical Engineering; To introduce students the world of virtual instrumentation and graphical programming environment (LabVIEW) which is dedicated to development of DAQ applications. To gain experience on functioning and using DAQ systems through numerous, real world, examples. To get closer acquaintance with the sensors, and digital acquisition software & hardware, in general, and methods of DACQ software developing and testing.

learning outcomes

Ability to integrate sensors and DAQ hardware in measurement chain in order to fulfill specific requirements in the field of mechanical engineering system testing & measurements. Ability to build and test software application (LabVIEW virtual instruments) for measurement and automation of various mechanical engineering systems. Practical knowledge in computer based measurements of fundamental engineering data

theoretical teaching

Architecture and basic principles of data acquisitions systems (DAQS); Definition and clarification of the fundamental terms in the field of measurement technique. Using FFT signal analysis; Fundamentals of signal filtering (Analog & Digital); Hardware components of the DAQ module −DAQ device; Basic principles of digital data acquisition; Temperature sensors and signal conditioning; Sensors of speed, force, acceleration and signal conditioning; Specific issues on digital input/output of DAQ devices; Counters and their usage for counting of discrete events and position measurement; Frequency/Period measurement of the digital signal by means of counters; Communications standards in measurement instrumentation (RS-232, RS-422/485, IEEE-488 (GPIB));

practical teaching

Introduction to the Virtual Instrumentation (VI) and LabVIEW development environment; Data flow in VI; Troubleshooting and Debugging Vis; Implementing a VI; Managing Hardware resources (Low and High-Level File I/O); Common Design Techniques and Patterns; Synchronization Techniques; Event Programming; Error Handling; Controlling the User Interface (VI Server Architecture; Control references); File I/O Techniques ; Improving an Existing VI; Creating and Distributing Applications; Student Project: Building a DAQ with given requirements;

*)National Instruments (NI) Labview courses “Core 1” & “Core 2” are incorporated in the theoretical and practical teaching of this course. This course is in compliance with the “LabVIEW Academia” program and therefore offers students all benefits stated in LabVIEW Academia agreement.

prerequisite

No particular requirements for attending this course

learning resources

Handouts: N. Miljić, Computer Based Measurements & Virtual Instrumentation
DACQs: National Instruments USB 6008, MyDAQ, PXI ,...
Graphical Development Environment: National Instruments LabView 2010 with modules and toolkits (LVA package)
Auxiliary platforms: Demo board for simulation of analog and digital signals; Universal Amplifying / Conditioning board for various sensors; Driver board for DC and step motors

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 18

active teaching (practical)

auditory exercises: 22
laboratory exercises: 19
calculation tasks: 0
seminar works: 0
project design: 3
consultations: 0
discussion and workshop: 1
research: 0

knowledge checks

check and assessment of calculation tasks: 4
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 3
colloquium, with assessment: 0
test, with assessment: 3
final exam: 2

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 45
laboratory exercises: 0
calculation tasks: 0
seminar works: 10
project design: 15
final exam: 30
requirements to take the exam (number of points): 42

references

Labview Core 1 & 2 Course Manual & Exercises, National Instruments
Jim Kring : LabVIEW for Everyone: Graphical Programming Made Easy and Fun (3rd Edition) , Prentice Hall, 2006, ISBN-13: 978-0131856721
Robert Bishop: LabVIEW 2009 Student Edition, Prentice Hall, 2010, ISBN13- 9780132141291
John Essick: Hands On Introduction to LabVIEW for Scientists and Engineers, Oxford University Press, USA, 2008, ISBN13- 9780195373950
Robert H. King:Introduction to Data Acquisition with LabVIEW,McGraw-Hill,2009,ISBN-13: 9780077299613

Ecology of Mobile Power Sources

ID: MSc-0320
teaching professor: Цветић Р. Милош
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 4
final exam: written+oral
parent department: internal combustion engines

goals

Acquiring basic knowledge of IC engine's influence on environment. Knowledge of pollutants origin in exhaust of IC engines and the ways of their reduction. Understanding of legal obligations and emission standards. Acquiring basic knowledge of noise sources in IC engines and the methods of noise reduction.

learning outcomes

Understanding the influence of human activities on environment, especially of harmful ones. Knowledge of pollutants formation chemistry, the greenhouse gases effects on global climate change, and noise of IC engines. Ability to apply solutions for pollutants and noise reduction.

theoretical teaching

Impact of IC engines on environment - general view (pollutants in exhaust, emission of greenhouse gases, engine noise). Chemistry of pollutants formation in exhaust emissions of spark-ignition and compression-ignition engines, and the ways of their reduction. Law regulations of engines exhaust pollutants emissions. Greenhouse gases emission and their impact on global warming. Engine noise, sources, standards, ways of reduction. Impact of engine design on pollutants emissions and engine noise.

practical teaching

a) Classroom sessions: 1. Numerical examples. 2. Review and analysis of in-cylinder and after-treatment solutions for pollutant exhaust gases reduction: EGR, three-way catalyst, catalyst after-treatment of diesel engine exhaust emission. 3. Review and analysis of engine design solutions for engine noise reduction.
b) Laboratory sessions: measurements of engine exhaust emissions with and without EGR.

prerequisite

Mandatory: passed exam Engine Working Processes.

learning resources

Handouts (PDF files); Instructions to carry out lab session and prepare and write report; numerical assignments examples; test bed with IC engine, measurement equipment and software for data acquisition.

number of hours

total number of hours: 45

active teaching (theoretical)

lectures: 18

active teaching (practical)

auditory exercises: 11
laboratory exercises: 3
calculation tasks: 2
seminar works: 0
project design: 0
consultations: 2
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 1
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 3
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 30
laboratory exercises: 20
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 50
requirements to take the exam (number of points): 30

references

Sher, E. (Ed.): Handbook of air pollution from internal combustion engines. Academic Press, San Diego, 1998. ISBN 0-12-639855-0.
Heywood J. B., Internal Combustion Engine Fundamentals, McGraw-Hill, New York, 1988. ISBN 0-07-028637-X.
Gruden, D.: Umweltschutz in der Automobilindustrie. Vieweg+Teubner, Wiesbaden, 2008. ISBN 978-3-8348-0404-4. (in german)

Ecology of Mobile Power Sources

ID: MSc-0707
teaching professor: Томић В. Мирољуб
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 4
final exam: written+oral
parent department: internal combustion engines

goals

Acquiring basic knowledge of IC engine's influence on environment. Knowledge of pollutants origin in exhaust of IC engines and the ways of their reduction. Understanding of legal obligations and emission standards. Acquiring basic knowledge of noise sources in IC engines and the methods of noise reduction.

learning outcomes

Understanding the influence of human activities on environment, especially of harmful ones. Knowledge of pollutants formation chemistry, the greenhouse gases effects on global climate change, and noise of IC engines. Ability to apply solutions for pollutants and noise reduction.

theoretical teaching

Impact of IC engines on environment - general view (pollutants in exhaust, emission of greenhouse gases, engine noise). Chemistry of pollutants formation in exhaust emissions of spark-ignition and compression-ignition engines, and the ways of their reduction. Law regulations of engines exhaust pollutants emissions. Greenhouse gases emission and their impact on global warming. Engine noise, sources, standards, ways of reduction. Impact of engine design on pollutants emissions and engine noise.

practical teaching

a) Classroom sessions: 1. Numerical examples. 2. Review and analysis of in-cylinder and after-treatment solutions for pollutant exhaust gases reduction: EGR, three-way catalyst, catalyst after-treatment of diesel engine exhaust emission. 3. Review and analysis of engine design solutions for engine noise reduction.
b) Laboratory sessions: 1. Measurements of engine exhaust emissions with and without EGR.

prerequisite

Mandatory: passed exam Engine Working Processes.

learning resources

Handouts (PDF files); Instructions to carry out lab session and prepare and write report; numerical assignments examples; test bed with IC engine, measurement equipment and software for data acquisition, exhaust gases analizers.

number of hours

total number of hours: 45

active teaching (theoretical)

lectures: 18

active teaching (practical)

auditory exercises: 11
laboratory exercises: 3
calculation tasks: 2
seminar works: 0
project design: 0
consultations: 2
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 1
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 3
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 35
laboratory exercises: 25
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 40
requirements to take the exam (number of points): 30

references

Sher, E. (Ed.): Handbook of air pollution from internal combustion engines. Academic Press, San Diego, 1998. ISBN 0-12-639855-0. (на енглеском)
Heywood J. B., Internal Combustion Engine Fundamentals, McGraw-Hill, New York, 1988. ISBN 0-07-028637-X. (на енглеском)
Gruden, D.: Umweltschutz in der Automobilindustrie. Vieweg+Teubner, Wiesbaden, 2008. ISBN 978-3-8348-0404-4. (на немачком)

Engine Design 1

ID: MSc-0242
teaching professor: Томић В. Мирољуб
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: internal combustion engines

goals

The aims of the course are to provide theoretical and practical study about engine dynamics, vibrations and design of engine parts. Through the evaluation of engine kinematics, dynamics and engine parts mechanical load and stress students acquires a sense for design of engine parts and complete engine. Basic knowledge about 3D modeling of engine parts and stress calculation using FEM is also provided and enable modern approach to engine design.

learning outcomes

The merger of theoretical knowledge of mechanics, basics of strength of constructions and machine elements and its applications on engine design. Training students for engine parts and systems design, modeling and calculation. The acquisition of basic theoretical and practical knowledge required for complete engine designing.

theoretical teaching

1. Kinematics of piston mechanism. Dynamics of piston mechanism and transfer of the forces through engine mechanism. Variations of engine torque and crankshaft rotational speed. Balancing of inertia forces of single cylinder engine and inertia forces and its moments of multi cylinder engines. 2. The role, design, choice of materials and evaluation of mechanical stress of engine piston group elements. Design, choice of materials and evaluation of mechanical stress of engine connecting rod. Design, choice of materials and evaluation of mechanical stress of engine crankshaft and crankshaft bearing. 3. Design and calculation of engine valve mechanism elements. 4. Problem of engine vibrations; vibration on the engine mounts; torsion vibrations of engine crankshaft.

practical teaching

1. Forces of engine piston mechanism; crankshaft tangential force and the variations of engine torque and crankshaft rotational speed, the role and calculation of engine flywheel; instructions for engine kinematics and dynamics calculation. 2. Examples of engine parts design and thermal and mechanical stress calculation; instructions for mechanical calculation of piston group, connecting rod and crankshaft. 3. Examples of gas exchange system design and instructions for calculation. 4. The application of 3-D modeling in engine parts design; the application of software tools for engine gas exchange system modeling and analyzing.

prerequisite

No prerequisites required.

learning resources

1. M.C. Živković: Internal combustion engines, part 2. Engine design 1, Kinematics and dynamics of piston mechanism. Faculty of Mech. Eng., Belgrade, 1983.
2. M.C. Živković, R. Trifunović: Internal combustion engines, part 2. Engine design 2, Design

and calculation of engine basic elements, Faculty of Mech. Eng., Belgrade, 1985.
3. M.Tomić: Engine design 1-Handouts, available in PDF format in IC engines department.
4. Sections of the engines. Various parts of the engines. Complete engines prepared for disassembling and assembling.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 16
laboratory exercises: 0
calculation tasks: 4
seminar works: 0
project design: 7
consultations: 3
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 2
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 5
colloquium, with assessment: 0
test, with assessment: 3
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 15
laboratory exercises: 0
calculation tasks: 15
seminar works: 0
project design: 30
final exam: 40
requirements to take the exam (number of points): 30

references

A. Kolchin, V. Demidov: Design of automotive engines, English translation, Mir Publishers Moscow, 1984.
Van Basshuysen, R., Schafer, F. (Editors): Internal Combustion Engine Handbook: Basics, Components, Systems, and Perspectives, SAE International, Warrendale, 2004. ISBN 978-0-7680-1139-5
Challen, B., Baranescu, R. (Editors): Diesel Engine Reference Book - 2nd ed., Butterworth-Heinemann, Woburn, 1999. ISBN 0-7506-2176-1.

Engineering Practice MSc - IC Engines

ID: MSc-0709
teaching professor: Томић В. Мирољуб
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 1
final exam: seminar works
parent department: internal combustion engines

goals

Acquiring practical knowledge of mechanical engineer's duties. Gaining knowledge about company's structure, management and quality system. Practical knowledge of manufacturing processes and corresponding machine tools. Broadening and acquiring new knowledges in the fields of IC engines research and testing.

learning outcomes

Understanding company's structure and connections between various company parts. To comprehend the importance of teamwork in everyday engineering practice. Gaining practical skills in the field of CAD/CAE/CAM/CAT.

theoretical teaching

Introduction. The role and importance of engineering practice in engineers education. Instructions on how to keep diary of practical training and how to write seminar paper. Recommendations on proper company selection for practical training. A two-stage practical training is expected: first stage in companies that design and build engines, engines parts and systems. Second stage will be in the Center of IC Engines, where students participates in design and completion of engine test beds, measuring systems and software production and testing, as well as participation in engine testing processes.

practical teaching

a) consultations during practical training; b) practical training b1. practical training in selected company (2/3 of practical training); b2. practical training in the Center of IC Engines (1/3 of practical training).

prerequisite

Passed exams: Engine Working Processes, Engine fuelling and ignition systems. Company's agreement to accept a student for practical training.

learning resources

Instructions for Engineering practice to carry out, (PDF file). Computers and licensed software in the Center of IC Engines. Test beds for engines and engine systems testing at the same center.

number of hours

total number of hours: 46

active teaching (theoretical)

lectures: 0

active teaching (practical)

auditory exercises: 0
laboratory exercises: 31
calculation tasks: 0
seminar works: 5
project design: 0
consultations: 5
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 3
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 0
final exam: 2

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 0
laboratory exercises: 20
calculation tasks: 0
seminar works: 30
project design: 0
final exam: 40
requirements to take the exam (number of points): 30

references

Engineering Practice MSc - IC Engines

ID: MSc-0237
teaching professor: Цветић Р. Милош
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 1
final exam: seminar works
parent department: internal combustion engines

goals

Acquiring practical knowledge of mechanical engineer's duties. Gaining knowledge about company's structure, management and quality system. Practical knowledge of manufacturing processes and corresponding machine tools. Broadening and acquiring new knowledges in the fields of IC engines research and testing.

learning outcomes

Understanding company's structure and connections between various company parts. To comprehend the importance of teamwork in everyday engineering practice. Gaining practical skills in the field of CAD/CAE/CAM/CAT.

theoretical teaching

Introduction. The role and importance of engineering practice in engineers education. Instructions on how to keep diary of practical training and how to write seminar paper. Recommendations on proper company selection for practical training. A two-stage practical training is expected: first stage in companies that design and build engines, engines parts and systems. Second stage will be in the Center of IC Engines, where students participates in design and completion of engine test beds, measuring systems and software production and testing, as well as participation in engine testing processes.

practical teaching

a) consultations during practical training; b) practical training b1. practical training in selected company (2/3 of practical training); b2. practical training in the Center of IC Engines (1/3 of practical training).

prerequisite

Passed exams: Engine Working Processes, Engine fuelling and ignition systems. Company's agreement to accept a student for practical training.

learning resources

Instructions for Engineering practice to carry out, (PDF file). Computers and licensed software in the Center of IC Engines. Test beds for engines and engine systems testing at the same center.

number of hours

total number of hours: 46

active teaching (theoretical)

lectures: 10

active teaching (practical)

auditory exercises: 0
laboratory exercises: 10
calculation tasks: 0
seminar works: 5
project design: 0
consultations: 6
discussion and workshop: 5
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 5
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 0
laboratory exercises: 20
calculation tasks: 0
seminar works: 40
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

Engine fuelling and ignition systems

ID: MSc-0294
teaching professor: Томић В. Мирољуб
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: internal combustion engines

goals

The aims of the course are to provide a comprehensive insight into the subject matter of Engine Fueling, Mixture formation and Ignition processes. Understanding the role, importance and principles of Engine Electronic Control. Broadening existing and acquiring new knowledge in hydrodynamics by studying high pressure phenomena occurring in fuel injection systems. Broadening knowledge in machine design by studying specific issues of high pressure pumps design principles. Broadening knowledge in electromechanics and electronics by studying processes occurring in Ignition Systems. Introduction into the field of Engine Sensors, Electronics and Mechatronics.

learning outcomes

Capabilities to develop, design, calculate and chose components of Engine Fueling and Ignition Systems. Capabilities to develop and organize maintenance procedures for both Fueling and Ignition Systems. Abilities related to specific issues of laboratory testing of Fueling and Ignition Systems and components. Developing practical skills for System set up and diagnostics.

theoretical teaching

Fuel spraying and mixture formation. Engine requirements regarding mixture strength. Carburetor basics – air & fuel flow, characteristics. Carburetor Auxiliary Systems. Fuel Injection Systems for SI Engines. Intake Port & Direct Fuel Injection, Hydraulic components, Sensors, Electronic Control Unit. Closed Loop Control. Fuel Injection Systems for CI Engines. High Pressure FI Pumps, Hydraulically operated Fuel Injectors and Nozzles. Common-Rail Fuel Injection Systems. Fuel Injection Dynamics. Electronic Control. Ignition Systems, Stages of operation, Ignition Spark - generation and characteristics. Spark Plug – Design and Characteristics.

practical teaching

Auditory exercises: Display and analysis of Carburetor based Engine fueling. Carburetor Dimensioning and Calculation. Display and analysis of SI Engines Fuel Injection Systems. Engine Sensors. Fuel Injector rated flow characteristics. Numeric examples for injection time determination. Injection time correction. Generation of basic Engine Injection Map. Diesel Fuel Injection Systems – numerical examples for HPP element & cam lobe design.

Laboratory exercises: Testing SI Engines Fuel Injection System components: Injector fuel rate determination (stationary, dynamic), Fuel Rail Dynamic Pressure measurement and analysis, Mass Air Flow-meter (MAFM) Characteristics measurement. Measurement and comparative analysis of MAFM and MAP sensor dynamics. Diesel Fuel Injection HP Pump Performance - Test Bench measurements. Measurement & Analysis of Diesel Fuel Injection System dynamics (injector pressure, injector needle travel). Measurement & Analysis of Ignition System Dynamics (ignition coil charge & discharge, ignition advance and spark plug jonization current).

prerequisite

Desirable: Good practical knowledge of Matlab/Simulink

learning resources

1. M. Tomić: IC Engines Fueling and Ignition Systems (in Serbian), Faculty of Mechanical Engineering, Belgrade, 2005.
2. M. Tomić, S. Popović: Extracts from Lectures (handouts), available in digital form
3. IC Engine testing Laboratory (with an engine on the test bed)
4. Flow Test Bench (in accordance to ISO 5167)
5. Diesel Injection System test Bench
6. DAQ System: National Instruments PXI-1042-RT8186/5401/6123/6229/4070/6602/8461
7. National Instruments LabView

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 11
laboratory exercises: 14
calculation tasks: 4
seminar works: 0
project design: 0
consultations: 1
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 4
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 6
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 25
laboratory exercises: 35
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 40
requirements to take the exam (number of points): 30

references

John Heywood: Internal Combustion Engine Fundamentals, Mc Graw-Hill, 1988, ISBN-13: 978-0070286375
H. P. Lenz: Mixture Formation in SI Engines, Springer Verlag, ISBN 3-211-82331-X
BOSCH Gasoline Engine Management, ISBN 0-7680-0510-8
BOSCH Diesel Engine Management, ISBN 0-7680-0509-4
BOSCH Automotive Sensors, 2002, ISBN-3-934584-50-0

IC ENGINES DESIGN 2

ID: MSc-0122
teaching professor: Томић В. Мирољуб
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 2
final exam: written+oral
parent department: internal combustion engines

goals

Acquiring new knowledge on role and design features of IC Engine Auxiliary systems - engine cooling & lubricating systems and starting devices. Developing skills to design and calculate working parameters of IC Engine Auxiliary Systems. Practical application and broadening knowledge in the field of Heat Transfer, Machine Design, Tribology and Engineering Materials.

learning outcomes

Understanding the Design of complex machines and Devices. Recognition and understanding of the importance of subsystems for proper functioning of the system as whole. Understanding the design principles and role of Cooling System, Lubrication System and Starter System. Capabilities to design and calculate vital components of IC Engine Auxiliary Systems.

theoretical teaching

IC Engine Cooling System: The role and Engine Thermal Load Issues;Liquid & Air Cooling Systems: Design and calculation; IC Engine Lubrication System: Design & Disposition; Lubricant Characteristics: Engine Requirements; Stribeck's Diagram; Lubrication Pump - Design & Calculation, Lubricant Filtration; IC Engine Starting Devices; Work required for Engine starting and running; Engine starting Devices Design Issues; Pneumatic Starters; Engine Crankshaft Rotation Reversing Devices - Design & Application Issues.

practical teaching

1. IC Engine Cooling System Design & Calculation - Waste Heat removed through Cooling System, Liquid & Air Cooling System Calculation Examples; 2. Engine Lubrication System Calculation Examples, Waste Heat removed through Lubrication System, Circulating Pump design and calculation;
Project Task: Design and calculation of Cooling/Lubricating System

prerequisite

Passed exam on course "IC Engines Processes"

learning resources

1. M.Tomić, M. Cvetić: Extracts from lectures (handouts) in digital form
2. S. Popović: Liquid & Air Cooling System Calculation Examples & Instructions in digital form

number of hours

total number of hours: 30

active teaching (theoretical)

lectures: 12

active teaching (practical)

auditory exercises: 8
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 3
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 1
colloquium, with assessment: 0
test, with assessment: 1
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 30
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 30
final exam: 40
requirements to take the exam (number of points): 30

references

Challen, B., Baranescu, R. (Editors): Diesel Engine Reference Book - 2nd ed., Butterworth-Heinemann, Woburn, 1999. ISBN 0-7506-2176-1.
Van Basshuysen, R., Schafer, F. (Editors): Internal Combustion Engine Handbook: Basics, Components, Systems, and Perspectives, SAE International, Warrendale, 2004. ISBN 978-0-7680-1139-5.
John Heywood: Internal Combustion Engine Fundamentals, Mc Graw-Hill, 1988, ISBN-13: 978-0070286375

IC Engines Mechatronics

ID: MSc-0310
teaching professor: Томић В. Мирољуб
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: internal combustion engines

goals

The aim of the course is to provide comprehensive insight into the specific subject matter of mechatronics systems used in IC Engines. To gain experience on functioning and using sensors and actuators specific for state of the art IC engines. To get closer acquaintance with the structure and architecture of the IC engine electronic control units (ECU), microcontrollers functions, in general, and methods of ECU software developing and testing.

learning outcomes

Ability to integrate specific electronic and mechanical engineering knowledge, with sound understanding of IC Engine mechatronic systems; More complete knowledge of IC Engine control; Ability to form IC Engine specific mechatronic system; Basic competence in ICE ECU programming and software testing; Knowledge in automotive bus communication, especially in ICE ECU data exchange.

theoretical teaching

Introduction to the mechatronics in IC Engines; Sensors and their characteristics; Measurement chains; Sensor calibration; "Intelligent" sensors; Sensing air/fuel ratio and exhaust gasses; Lubrication Oil monitoring sensor; Sensors of rotational and linear position and speed; Mass air flow sensors; IC Engine temperature and pressure sensors; Knock sensors; Actuators - classification; Power actuators (high voltage/current) and basics of power electronics; Ignition and Fuel injection system mechatronic components; Idle control; Waste gate and VVT actuators; AI/AO, DI/DO signals on uC; Digital signal acquisition; Peripheral uC devices; uC Communication interfaces; uC Hardware; Specific features of IC Engine uC; IC Engine specific functions realized on TPU blocks of Motorola (Freescale) uC; Software and programming methods - development environment, compiling, debugging; Software testing - SIL, PIL, HIL; Automatic control (basic principles repetition); Air/Fuel ratio control; Knock control; Adaptive control algorithms; Principles of Model Based IC Engine control and diagnostics; Engine speed based diagnostics and control algorithms; ICE ECU communication interfaces; Automotive communication buses and protocols - CAN, LIN, Flex Ray, K-Line, CCP;

practical teaching

In vivo demonstration of IC Engine mechatronic systems; Exercises with various automotive, IC Engine specific, sensors and actuators; uC programming (Freescale MPC 566, and MC68332) - basic ICE (gasoline fuel injection) control application based on TPU functions; SIL and PIL simulations; CAN communication - ECU calibration via CCP; IC Engine sensors and digital acquisition - Calculation tasks;

prerequisite

Exams passed on course “Electrical and electronics engineering” and at least one of : “ICE Fundamentals”, or “Engine fuelling and ignition systems”

learning resources

1. S.J. Popović, N. Miljić Handouts
2. IC Engine testing Laboratory (with an engine on the test bed)
3. DAQ System: National Instruments PXI-1042-RT8186/5401/6123/6229/4070/6602/8461
4. Phytec pc-565 (Freescale MPC 565)
5. MCT GmbH Mega332 (Freescale MC68332)
6. National Instruments LabView
7. Metrowerks CodeWarrior 8.x
8. WinEco MCT GmbH

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 14
laboratory exercises: 12
calculation tasks: 3
seminar works: 0
project design: 0
consultations: 1
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 2
check and assessment of lab reports: 2
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 6
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 30
laboratory exercises: 15
calculation tasks: 15
seminar works: 0
project design: 0
final exam: 40
requirements to take the exam (number of points): 30

references

W. Bolton, Mechatronics, Pearson-Prentice Hall, 2003, ISBN 0 131 21633 3
U. Kincke, L. Nielsen: Automotive Control Systems, Springer Verlag, 2004, ISBN 3-540-23139-0;
R. Isermann, Modelgestuetzte Steuerung, Regelung und Diagnose von Verbrennungsmotoren, Springer Verlag, 2003, ISBN-10:3540442863, ISBN-13: 978-3540442863
BOSCH Gasoline Engine Management, ISBN 0-7680-0510-8
BOSCH Automotive Sensors, 2002, ISBN-3-934584-50-0

IC Engine Testing

ID: MSc-0449
teaching professor: Цветић Р. Милош
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: internal combustion engines

goals

To cover the basic knowledge of experimental work in the field of IC Engines. Broadening of measuring techniques knowledge, used in engineering, through acquaintance with specific measuring equipment, devices and software tools used for IC engine testing. Developing of skills required for developing of IC engines test facilities, choice of adequate measuring equipment, devices and auxiliaries for funding IC engine test bench. Developing of skills required for planning, organization and conducting an IC Engine testing.

learning outcomes

Practical knowledge in IC engine testing procedures, operations and data analysis. Ability in solving and analysis of practical engineering tasks related to IC engine testing and IC engine test measuring equipment and facilities

theoretical teaching

Measurement of: Torques and forces; rotational speed and acceleration; gas and fuel mass and volumetric flow (with anemometry); temperatures and pressures; IC engine indicating techniques and measurement equipment; IC Engine exhaust analysis; Engine dynamometers; Fundamentals of IC Engines test benches design; IC engine testing standards, procedures and operations

practical teaching

Measurement errors and uncertainty (examples with calculation tasks); Introduction to Labview (NI) measurement and programming environment; Calibration of measurement chains; Preparation for laboratory tasks (description of measuring equipment and chains used, task instructions):

Getting acquaintance with the Labview environment and its usage in IC engine testing tasks; Calibration of specific transducer measurement chain (torque, pressure, temperature,...); IC Engine in cylinder pressure indicating; Measurements on engine test bench - gathering data for BSFC characteristics map; Determining the energy balance of an ICE

prerequisite

Passed exam on course “IC engine working processes”

learning resources

-Živković, M.C, Trifunović, R.: IC Engine Testing (on Serbian), FME Belgrade
- Lecture Handouts, Lab Exercises Instructions, Calculus examples (pdf)
- Laboratories equipped with IC Engine testing equipement (fully equiped IC Engine test benches)
- DAQ Measurement equipement (National Instruments PXI based system with Labview

Developement software)

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 12
laboratory exercises: 14
calculation tasks: 4
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 2
check and assessment of lab reports: 6
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 2
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 20
laboratory exercises: 30
calculation tasks: 5
seminar works: 0
project design: 0
final exam: 45
requirements to take the exam (number of points): 35

references

Grohe, H.: Messen an Verbrennungsmotoren, Vogel-Verlag, Würzburg, 1979. ISBN 3-8023-0087-4. (in german)
Plint, M., Martyr, A.: Engine testing - Theory and practice, Butterworth-Heinemann, Oxford, 1997. ISBN 0-7506-1668-7.
Holman, J. P.: Experimental methods for engineers. McGraw-Hill, 1984. ISBN 0-07-029613-8.
Nachtigal, C. L.: Instrumentation and control. John Wiley & Sons, Inc., New York, 1990. ISBN 0-471-88045-0.

IC Engine Testing

ID: MSc-0705
teaching professor: Томић В. Мирољуб
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: internal combustion engines

goals

To cover the basic knowledge of experimental work in the field of IC Engines. Broadening of measuring techniques knowledge, used in engineering, through acquaintance with specific measuring equipment, devices and software tools used for IC engine testing. Developing of skills required for developing of IC engines test facilities, choice of adequate measuring equipment, devices and auxiliaries for funding IC engine test bench. Developing of skills required for planning, organization and conducting an IC Engine testing.

learning outcomes

Practical knowledge in IC engine testing procedures, operations and data analysis. Ability in solving and analysis of practical engineering tasks related to IC engine testing and IC engine test measuring equipment and facilities

theoretical teaching

Measurement of: Torques and forces; rotational speed and acceleration; gas and fuel mass and volumetric flow (with anemometry); temperatures and pressures; IC engine indicating techniques and measurement equipment; IC Engine exhaust analysis; Engine dynamometers; Fundamentals of IC Engines test benches design; IC engine testing standards, procedures and operations

practical teaching

Measurement errors and uncertainty (examples with calculation tasks); Introduction to Labview (NI) measurement and programming environment; Calibration of measurement chains; Preparation for laboratory tasks (description of measuring equipment and chains used, task instructions):

Getting acquaintance with the Labview environment and its usage in IC engine testing tasks; Calibration of specific transducer measurement chain (torque, pressure, temperature,...); IC Engine in cylinder pressure indicating; Measurements on engine test bench - gathering data for BSFC characteristics map; Determining the energy balance of an ICE

prerequisite

Passed exam on course “IC engine working processes”

learning resources

-Živković, M.C, Trifunović, R.: IC Engine Testing (on Serbian), FME Belgrade
- Lecture Handouts, Lab Exercises Instructions, Calculus examples (pdf)
- Laboratories equipped with IC Engine testing equipement (fully equiped IC Engine test benches)
- DAQ Measurement equipement (National Instruments PXI based system with Labview

Developement software)

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 12
laboratory exercises: 14
calculation tasks: 4
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 2
check and assessment of lab reports: 6
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 2
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 20
laboratory exercises: 30
calculation tasks: 10
seminar works: 0
project design: 0
final exam: 40
requirements to take the exam (number of points): 30

references

Plint, M., Martyr, A.: Engine testing - Theory and practice, Butterworth-Heinemann, Oxford, 1997. ISBN 0-7506-1668-7. (на енглеском)
Grohe, H.: Messen an Verbrennungsmotoren, Vogel-Verlag, Würzburg, 1979. ISBN 3-8023-0087-4. (на немачком)
Holman, J. P.: Experimental methods for engineers. McGraw-Hill, 1984. ISBN 0-07-029613-8. (на енглеском)
Nachtigal, C. L.: Instrumentation and control. John Wiley & Sons, Inc., New York, 1990. ISBN 0-471-88045-0. (на енглеском)

Internal combustion engines

ID: MSc-0651
teaching professor: Томић В. Мирољуб
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: internal combustion engines

goals

The aims of the course are to provide a comprehensive insight into the subject matter of Internal Combustion Engines (theoretical operating cycle, real operating cycle, engine systems, engine operating characteristics). It is intended for students of the Internal Combustion Engines module as an in-depth introduction into studies of specific areas of Internal Combustion Engines, as well as for students of modules which require knowledge of Internal Combustion Engines as a power unit (Motor vehicles, Naval Architecture, Railway Mechanical Engineering, and Material Handling, Constructions and Logistics).

learning outcomes

Acquired theoretical and practical knowledge of Internal Combustion Engines. The ability to link fundamental engineering branches of thermodynamics, fluid mechanics, mechanics, strength of materials etc. into a complex unit such as engine. The ability of competent approach to engine selection, organization of exploitation and maintenance. Acquisition of solid base for tackling specific problems, design and construction of Internal Combustion Engines.

theoretical teaching

Introductory considerations. Analysis of engine ideal thermodynamic cycles. Engine real operating cycle: gas exchange process, combustion process in Otto and Diesel engines. Engine working parameters: indicated parameters, mechanical losses, effective parameters. Engine supercharging: role, types and characteristics of supercharging systems. Engine dynamic problems: gas and inertia forces, force transfer through engine mechanism, non-uniformity of angular velocity, balancing of inertia forces and their moments. Engine operating characteristics: with respect to engine speed and load, propeller type characteristics, universal characteristics. Engine ecological problems: toxic components of exhausts in Otto and Diesel engines, and the ways to reduce them.

practical teaching

Auditory exercises: Analysis of different type engine design characteristic. Engine working substances: types of fuels and their properties. Numerical examples in engine thermodynamic cycles. Fuel supply systems for Otto and Diesel engines. Numerical examples of engine working parameters, engine charging and supercharging and heat balance. Numerical examples of engine mechanism kinematics and dynamics. Engine systems and devices: ignition system, starting system, cooling system – air-cooled and liquid-cooled engines, lubricating system. Fundamentals of engine testing and preparation of laboratory exercises for engine testing.

Laboratory exercises: Fuel supply systems for Otto and Diesel engines and engine electrical systems. Testing of engine characteristics on the test bench.

prerequisite

No prerequisites required.

learning resources

1. M. Tomić, S. Petrović: Internal Combustion Engines, FME, Belgrade, 2004, /In Serbian/ available at the FME Library
2. M. Tomić & S. Popović: Lecture notes (handouts) - Basics of Internal Combustion Engines, available in e-form in pdf on the site of the Chair of Internal Combustion Engines
3. IC Engine testing Laboratory (with an engine on the test bed)
4. Measuring-acquisition system: National Instruments PXI-1042-RT8186/5401/6123/6229/4070 /6602/8461
5. National Instruments LabView

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 9
laboratory exercises: 8
calculation tasks: 10
seminar works: 0
project design: 0
consultations: 3
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 5
check and assessment of lab reports: 1
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 4
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 30
laboratory exercises: 20
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 40
requirements to take the exam (number of points): 30

references

Miroljub Tomić, Stojan Petrović: Motori sa unutrašnjim sagorevanjem, Fac. of Mech. Engineering, Belgrade,ISBN 978-86-7083-646-4
Richard Stone: Introduction to IC Engines, SAE International, ISBN-13: 978-0768004953
John Heywood: Internal Combustion Engine Fundamentals, Mc Graw-Hill, 1988, ISBN-13: 978-0070286375
C. R. Ferguson: Internal Combustion Engines, J.Wiley & Sons 1986, ISBN 0-471-88129-5

Marine Engines

ID: MSc-0706
teaching professor: Томић В. Мирољуб
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 4
final exam: written+oral
parent department: internal combustion engines

goals

The target of this subject is to give a comprehensive insight into the specific matter of IC marine engines, two-stroke, as well as four- stroke ones, and especially of high power engines with complex engine mechanism. The subject is intended for the students of Shipbuilding department who will be given an introduction for further later research into construction specifications of this class of engines and engine systems during professional practical work experience.

learning outcomes

General specifications: Adopted basic theoretical and practical knowledge in the field of IC marine engines where fundamental and applied scientific disciplines are entangled. Students acquire basic ability for competent approach to the choice, organization of exploitation and maintenance of engines in the field of marine engine systems

theoretical teaching

1.Introductory considerations 2.Specifications of the construction of marine engine parts- immovable and movable, marine engine distribution system 3.Fuel supply system and the supercharging system of the engine. 4. System of lubrication and cooling of the engine. Function, importance and types of lubricating oils for marine engines. Liquid cooling system. Air cooling system. 5. Engine starting and reversing system and operating characteristics of marine engines. Propelling characteristic of the engine. Optimization of the coupling: engine-propeller. 6. Marine engine vibrations. Torsion oscillations of the crankshaft and the transferring shafts. Possibilities of resonance occurrence and the method of its avoidance. 7. Choice of the marine engine as the most important marine driving machine.8. Presentation of marine engine supercharge systems. 9. Marine engine fundaments.

practical teaching

a) Auditory training: 1. Construction of marine engines. Presentation and analysis of different conceptions, and the construction of marine driving engines, from the lowest to the highest powers. 2. Marine diesel engine fuel supply system. Mechanical regulation systems (pump-pipe- injector, pump- injector), accumulator (common rail) systems, electronic regulated systems. 3.Supercharge engine system- presentation and analysis of the construction of the physical model of turbocharger. 4. Governors of the RPM of marine engines – function and types, division according to the place of assembly, analysis of the construction and the governor operational system. Analysis of the possibilities of electronic governor in optimization of marine diesel engine operating area marine diesel engines.
b) Laboratory training: Engine testing- measuring of the propelling characteristics of the engine.

prerequisite

No prerequisites required.

learning resources

Handouts, available in electronic version in PDF format on the site of IC Engine department. Instructions for the demonstration of laboratory experiment and electronic report writing laboratory installation-test bench with IC engine, measuring equipment and the software for measuring data acquisition.

number of hours

total number of hours: 45

active teaching (theoretical)

lectures: 12

active teaching (practical)

auditory exercises: 18
laboratory exercises: 4
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 2
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 2
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 4
final exam: 3

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 25
laboratory exercises: 25
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 40
requirements to take the exam (number of points): 30

references

Handouts, available in electronic version in PDF format on the site of IC Engine department.
Woodyard, D. F. (Ed.): Pounder's marine diesel engines and gas turbines - 8th edn., Elsevier Butterworth-Heinemann, Oxford,Burlington, 2004. ISBN 0-7506-5846-0.
Pounder, C. C.: Marine Diesel Engine, Butterworth & Co (Publishers) Ltd, Great Britain, 1972.

Marine Engines

ID: MSc-0238
teaching professor: Цветић Р. Милош
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 4
final exam: written+oral
parent department: internal combustion engines

goals

The target of this subject is to give a comprehensive insight into the specific matter of IC marine engines, two-stroke, as well as four- stroke ones, and especially of high power engines with piston mechanism with crosshead. The subject is intended for the students of Shipbuilding department who will be given an introduction for further later research into construction specifications of this class of engines and engine systems during professional practical work experience.

learning outcomes

General specifications: Adopted basic theoretical and practical knowledge in the field of IC marine engines where fundamental and applied scientific disciplines are entangled. Students acquire basic ability for competent approach to the choice, organization of exploitation and maintenance of engines in the field of marine engine systems.

theoretical teaching

1.Introductory considerations 2.Specifications of the construction of marine engine parts-immovable and movable, marine engine distribution system 3.Fuel supply system and the supercharging system of the engine. 4. System of lubrication and cooling of the engine. Function, importance and types of lubricating oils for marine engines. Liquid cooling system. Air cooling system. 5. Engine starting and reversing system and operating characteristics of marine engines. Propelling characteristic of the engine. Optimization of the coupling: engine-propeller. 6. Marine engine vibrations. Torsional oscillations of the crankshaft and the transferring shafts. Possibilities of resonance occurrence and the method of its avoidance. 7. Choice of the marine engine as the most important marine driving machine.8. Presentation of marine engine supercharge systems. 9. Fundamenting of marine engine.

practical teaching

a) Auditory training: 1. Construction of marine engines. Presentation and analysis of different conceptions, and the construction of marine driving engines, from the lowest to the highest powers. 2. Marine diesel engine fuel supply system. Mechanical regulation systems (pump-pipe- injector, pump- injector), accumulator (common rail) systems, electronic regulated systems. 3.Supercharge engine system- presentation and analysis of the construction of the physical model of turbocharger. 4. Governors of the RPM of marine engines – function and types, division according to the place of assembly, analysis of the construction and the governor operational system. Analysis of the possibilities of electronic governor in optimization of marine diesel engine operating area marine diesel engines.
b) Laboratory training: Engine testing- measuring of the propelling characteristics of the engine.

prerequisite

To attend and pass the exam-IC Engines Fundamentals;for students of Module IC Engines to attend and pass the exam-Engines Working Processes.

learning resources

Handouts, available in electronic version in pdf format. Instructions for the demonstration of laboratory experiment and report writing (pdf). Laboratory installation-test bench with IC engine, measuring equipment and the software for measuring data acquisition.

number of hours

total number of hours: 45

active teaching (theoretical)

lectures: 18

active teaching (practical)

auditory exercises: 12
laboratory exercises: 4
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 2
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 1
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 3
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 30
laboratory exercises: 20
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 50
requirements to take the exam (number of points): 30

references

C.C.Pounder: Marin Diesel Engines, Fifth edition, Butterworth&Co (Publishers) Ltd, 1972, ISBN 0 408 00077 5
C.T.Wilbur, D.A.Wight: Marine Diesel Engines, Sixth edition, Butterworth&Co (Publishers) Ltd, 1984, ISBN 0-408-01136-X

Reciprocating Compressor

ID: MSc-0708
teaching professor: Томић В. Мирољуб
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: internal combustion engines

goals

Acquiring basic knowledge on reciprocating compressors. Increased knowledge of thermodynamics through the study of compression of real gases, gas mixtures and moist gases, and the study of actual working cycles of reciprocating compressors. Expansion and acquisition of new knowledge in the field of Engineering, through the study of basic structural elements, systems and auxulary equipment of reciprocating compressors. Developing skills for the design of reciprocating compressors, selection, testing, installation and maintenance in service.

learning outcomes

Understanding of complex real working cycle of reciprocating compressors working with real gases; Understanding of complex structural design of such machines. Development of critical thinking which leads to sound understanding of cause-effect relationship between working cycle and machine design; Ability to design and accomplish selection, testing, installation and maintenance of reciprocating compressors in service.

theoretical teaching

Reciprocating mechanism kinematics and dynamics; Unevenness of Reciprocating Compressor crankshaft speed; Compressor and crankshaft balance; Theoretical thermodynamic fundamentals of compression processes of ideal and real gases, gas mixtures and moist gases; Theoretical work cycle of piston compressor without dead volume; Actual working cycle of single-stage piston compressor, working media and compressor parameters; Multi-stage compression; Determining compressor size and working space dimensions; Compressor systems and auxiliary equipment; Flow and pressure control of Piston Compressors; Design analysis of various Reciprocating Compressors types; Fundamentals of Compressor Maintenance;

practical teaching

Calculus examples covering theoretical backgrounds of Reciprocating Compressor working process; Evaluation and analysis of various Reciprocating Compressors, its main parts, systems and auxiliary equipment; Insight in Rotational Piston Compressors; Introduction to the Reciprocating compressor testing and instructions for laboratory exercises (Experimentally determining compressor isentropic and volumetric efficiency; Determining of flow coefficients of compressor plate valve)

prerequisite

Basic knowledge of Thermodynamics

learning resources

- M. Cvetić, N. Miljic : Handouts from Lectures and Exercises
- R. Jankov: Piston Compressors, Faculty of Mechanical Engineering, Belgrade, 5th edition, 1990

- Laboratory for Piston Compressor testing equipped with DAQ measurement equipment and software
- Compressor Valve flow test bench

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 20

active teaching (practical)

auditory exercises: 16
laboratory exercises: 4
calculation tasks: 20
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 6
check and assessment of lab reports: 2
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 2
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 10
laboratory exercises: 15
calculation tasks: 25
seminar works: 0
project design: 0
final exam: 40
requirements to take the exam (number of points): 30

references

R. Jankov: Piston Compressors, Faculty of Mechanical Engineering, Belgrade, 5th edition, 1990, (on Serbian)
Bloch, H. P, Hoefner, J. J.: Reciprocating compressors: operation and maintenance, Butterworth-Heinemann, Woburn, 1996. ISBN 0-88415-525-0.
Brown, R. N.: Compressors: selection & sizing – 2nd ed., Butterworth-Heinemann, Woburn, 1997. ISBN 0-88415-164-6.
Bendler, H., Spengler, H. (ed.): Technisches Handbuch Verdichter, Veb Verlag Technik, Berlin,1986.
Frenkel, M., I.: Kolbenverdichter, Veb Verlag Technik, Berlin,1969.

Reciprocating Compressors

ID: MSc-0516
teaching professor: Цветић Р. Милош
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: internal combustion engines

goals

Acquiring basic knowledge on reciprocating compressors. Increased knowledge of thermodynamics through the study of compression of real gases, gas mixtures and moist gases, and the study of actual working cycles of reciprocating compressors. Expansion and acquisition of new knowledge in the field of Engineering, through the study of basic structural elements, systems and auxulary equipment of reciprocating compressors. Developing skills for the design of reciprocating compressors, selection, testing, installation and maintenance in service.

learning outcomes

Understanding of complex real working cycle of reciprocating compressors working with real gases; Understanding of complex structural design of such machines. Development of critical thinking which leads to sound understanding of cause-effect relationship between working cycle and machine design; Ability to design and accomplish selection, testing, installation and maintenance of reciprocating compressors in service.

theoretical teaching

Reciprocating mechanism kinematics and dynamics; Unevenness of Reciprocating Compressor crankshaft speed; Compressor and crankshaft balance; Theoretical thermodynamic fundamentals of compression processes of ideal and real gases, gas mixtures and moist gases; Theoretical work cycle of piston compressor without dead volume; Actual working cycle of single-stage piston compressor, working media and compressor parameters; Multi-stage compression; Determining compressor size and working space dimensions; Compressor systems and auxiliary equipment; Flow and pressure control of Piston Compressors; Design analysis of various Reciprocating Compressors types; Fundamentals of Compressor Maintenance;

practical teaching

Calculus examples covering theoretical backgrounds of Reciprocating Compressor working process; Evaluation and analysis of various Reciprocating Compressors, its main parts, systems and auxiliary equipment; Insight in Rotational Piston Compressors; Introduction to the Reciprocating compressor testing and instructions for laboratory exercises (Experimentally determining compressor isentropic and volumetric efficiency; Determining of flow coefficients of compressor plate valve)

prerequisite

Basic knowledge of Thermodynamics

learning resources

- M. Cvetić, N. Miljic : Handouts from Lectures and Exercises (PDF files)
- R. Jankov: Piston Compressors, Faculty of Mechanical Engineering, Belgrade, 5th edition, 1990

(in serbian)
- Laboratory for Piston Compressor testing equipped with DAQ measurement equipment and software
- Compressor Valve flow test bench

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 20

active teaching (practical)

auditory exercises: 16
laboratory exercises: 4
calculation tasks: 20
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 6
check and assessment of lab reports: 2
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 2
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 10
laboratory exercises: 15
calculation tasks: 25
seminar works: 0
project design: 0
final exam: 40
requirements to take the exam (number of points): 35

references

Bloch, H. P, Hoefner, J. J.: Reciprocating compressors: operation and maintenance, Butterworth-Heinemann, Woburn, 1996. ISBN 0-88415-525-0.
Brown, R. N.: Compressors: selection & sizing – 2nd ed., Butterworth-Heinemann, Woburn, 1997. ISBN 0-88415-164-6.
Bendler, H., Spengler, H. (ed.): Technisches Handbuch Verdichter, Veb Verlag Technik, Berlin,1986.
Frenkel, M., I.: Kolbenverdichter, Veb Verlag Technik, Berlin,1969.

Supercharging of IC Engines

ID: MSc-0701
teaching professor: Томић В. Мирољуб
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: internal combustion engines

goals

Acquiring new knowledge on role and importance of turbocharging in IC Engines. Developing skills to calculate parameters of supercharging and match compressor/turbine to desired engine performance. Broadening knowledge of thermodynamics by studying compressor/turbine performance characteristics and processes occuring in intercooler. Broadening knowledge in machine design by studying specific issues of turbocharger design principles.

learning outcomes

Understanding the reality of Heat Engines working cycles and complexity of their design. Establishing the Cause & Effect relationship between working cycle and machine design. Capabilities to calculate parameters of IC Engine Supercharging, to make proper selection of Supercharging System components (compressor, turbine, intercooler, Waste-Gate). Abilities related to specific issues of laboratory testing of Supercharging System Components.

theoretical teaching

1. Definitions and Survey of IC Engine Supercharging Methods; 2. Matching Flow Capacities and Characteristics of IC Engine and Charging Compressor; 3. Mechanical Supercharging; 4. Exhaust Gas Turbocharging; 5. Intercooling; 6. Calculation of Supercharging; Supercharging by means of Gasdynamic effects; 7. Design of Turbochargers; 8. Special issues and specific solutons of Supercharging;

practical teaching

a) 1. Numerical examples in IC Engines Supercharging 2. Display & Analysis of Supercharging Methods, Design and Performance Characteristics of Compressors, Turbines & Intercoolers; 3. Preparation for Laboratory Task; 4. Principles of Modeling & Simulation of Supercharging System Components in Matlab/Simulink; Simulation of Supercharged IC Engine using Matlab/Simulink;

b)Student Project Task: Calculation of Supercharging System and matching Compressor/Turbine Characteristics to desired IC Engine Performance.

c) Laboratory Task: - Testing Compressor on Test Bench;

prerequisite

Passed exam on course "IC Engines processes".
Good practical knowledge of Matlab/Simulink

learning resources

1. M. Cvetić: Extracts from lectures (handouts) in e-form
2. S. Popović: Numerical examples, in e-form

3. IC Engine testing Laboratory (with an engine on the test bed)
4. Turbo-compressor Flow test bench
5. DAQ System: National Instruments PXI-1042-RT8186/5401/6123/6229/4070/6602/8461
6. National Instruments LabView Graphical Development Environment
7. Matlab/Simulink Software Package

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 5
laboratory exercises: 5
calculation tasks: 14
seminar works: 0
project design: 2
consultations: 4
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 2
check and assessment of lab reports: 3
check and assessment of seminar works: 0
check and assessment of projects: 3
colloquium, with assessment: 0
test, with assessment: 2
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 10
laboratory exercises: 15
calculation tasks: 15
seminar works: 0
project design: 20
final exam: 40
requirements to take the exam (number of points): 30

references

H. Hiereth, P. Prenninger: Charging the Internal Combustion Engine, Springer Verlag 2003, ISBN 978-3-211-33033-3
Watson, N., Janota, M. S.: Turbocharging the Internal Combustion Engine. Macmillan Press, London, 1982. ISBN 0-333-24290-4.
Zinner, K.: Aufladung von Verbrennungsmotoren. Springer-Verlag, Berlin, 1985. ISBN 3-540-15902-9. (in german)
John Heywood: Internal Combustion Engine Fundamentals, ISBN-13: 978-0070286375.

Supercharging of IC Engines

ID: MSc-0247
teaching professor: Цветић Р. Милош
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: internal combustion engines

goals

Acquiring new knowledge on role and importance of turbocharging in IC Engines. Developing skills to calculate parameters of supercharging and match compressor/turbine to desired engine performance. Broadening knowledge of thermodynamics by studying compressor/turbine performance characteristics and processes occuring in intercooler. Broadening knowledge in machine design by studying specific issues of turbocharger design principles.

learning outcomes

Understanding the reality of Heat Engines working cycles and complexity of their design. Establishing the Cause & Effect relationship between working cycle and machine design. Capabilities to calculate parameters of IC Engine Supercharging, to make proper selection of Supercharging System components (compressor, turbine, intercooler, Waste-Gate). Abilities related to specific issues of laboratory testing of Supercharging System Components.

theoretical teaching

1. Definitions and Survey of IC Engine Supercharging Methods; 2. Matching Flow Capacities and Characteristics of IC Engine and Charging Compressor; 3. Mechanical Supercharging; 4. Exhaust Gas Turbocharging; 5. Intercooling; 6. Calculation of Supercharging; Supercharging by means of Gasdynamic effects; 7. Design of Turbochargers; 8. Special issues and specific solutons of Supercharging;

practical teaching

Display & Analysis of Supercharging Methods; Design and Performance Characteristics of Compressors, Turbines & Intercoolers; Preparation for Laboratory Task; Principles of Modeling & Simulation of Supercharging System Components in Matlab/Simulink; Simulation of Supercharged IC Engine using Matlab/Simulink;

Laboratory Task: - Testing Compressor on Test Bench;

Student Project Task: Calculation of Supercharging System and matching Compressor/Turbine Characteristics to desired IC Engine Performance.

prerequisite

Passed exam on course "IC Engines processes".
Good practical knowledge of Matlab/Simulink

learning resources

1. M. Cvetić: Extracts from lectures (handouts) in e-form
2. S. Popović: Numerical examples, in e-form
3. IC Engine testing Laboratory (with an engine on the test bed)

4. Turbo-compressor Flow test bench
5. DAQ System: National Instruments PXI-1042-RT8186/5401/6123/6229/4070/6602/8461
6. National Instruments LabView
7. Matlab/Simulink

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 5
laboratory exercises: 5
calculation tasks: 14
seminar works: 0
project design: 2
consultations: 4
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 2
check and assessment of lab reports: 3
check and assessment of seminar works: 0
check and assessment of projects: 3
colloquium, with assessment: 0
test, with assessment: 2
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 10
laboratory exercises: 10
calculation tasks: 15
seminar works: 0
project design: 15
final exam: 50
requirements to take the exam (number of points): 35

references

H. Hiereth, P. Prenninger: Charging the Internal Combustion Engine, Springer Verlag 2003, ISBN 978-3-211-33033-3
Watson, N., Janota, M. S.: Turbocharging the Internal Combustion Engine. Macmillan Press, London, 1982. ISBN 0-333-24290-4.
Zinner, K.: Aufladung von Verbrennungsmotoren. Springer-Verlag, Berlin, 1985. ISBN 3-540-15902-9. (in german)
John Heywood: Internal Combustion Engine Fundamentals, ISBN-13: 978-0070286375.

Engine Design Project

ID: MSc-0232
teaching professor: Цветић Р. Милош
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: internal combustion engines

goals

Gaining experience through practical work on the design of IC engines. The practical application of knowledge from previous IC engines courses, expansion and acquisition of new knowledge in the field of design and calculation of machines, materials and production methods of machine parts. Introduction to modern methods of design in mechanical engineering, especially in the field of IC engines. Understanding and gaining practical experience in working with computer aided design and calculation methods (CAD - 2D, 3D, CAE).

learning outcomes

Understanding the whole complex mechanical structures, the connection of individual parts and components, ability to design a functional and well-designed machines. The ability of practical application of modern software tools for designing in mechanical engineering. The capability to design, making good material and production methods selection of the most important parts of internal combustion engines. Selection and dimensioning of auxiliary systems and components needed for proper engine functioning.

theoretical teaching

The role of standardization and unification in the IC engine design. Phases of the classical approach to the design of the engine (sequential design). Definition of technical terms; Selection of the most important process and operating parameters in the construction of a new engine. Making of preliminary design and the main engine project. Preparation of workshop drawings. Testing and refinement of the prototype design; Simultaneous (parallel) design; Computer aided design; Technology of rapid prototyping; Mathematical modeling of working processes of Otto and Diesel-engine; Modeling of the fundamental elements of the Engine structure, the calculation by means of FEM.

practical teaching

Development of the project of the IC Engine - assembly drawings of the cross and longitudinal sections; 3D modeling (CAD) of one of the most important parts of the Engine and making workshop documentation for that part; Consultations in the preparation of the project.

prerequisite

Engine Working Processes, IC Engine Design 1, Skills in using CAD software

learning resources

- M. Cvetić: Extracts from lectures (handouts)
- 2D & 3D CAD CAE Software & Workstations

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 30
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 10
colloquium, with assessment: 0
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 70
final exam: 30
requirements to take the exam (number of points): 30

references

Basshuysen, R. von, Schaefer, F.: Internal Combustion Engine Handbook, SAE, Warrendale, 2004. ISBN 0-7680-1139-6.
Challen, B., Baranescu, R. (ed.): Diesel Engine Reference Book, 2nd Ed., Butterworth-Heinemann, Woburn, 1999. ISBN 0 7506 2176 1.
Mollenhauer, K., Tschoeke, H. (ed.): Handbook of Diesel Engines. Springer-Verlag, Berlin, Heidelberg, 2010. ISBN 978-3-540-89082-9.
Yamagata, H.: The science and technology of materials in automotive engines. Woodhead Publishing Limited, Cambridge, 2005. ISBN 1-85573-742-6.

Engine Design Project

ID: MSc-0704
teaching professor: Томић В. Мирољуб
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: project design
parent department: internal combustion engines

goals

Gaining experience through practical work on the design of IC engines. The practical application of knowledge from previous IC engines courses, expansion and acquisition of new knowledge in the field of design and calculation of machines, materials and production methods of machine parts. Introduction to modern methods of design in mechanical engineering, especially in the field of IC engines. Understanding and gaining practical experience in working with computer aided design and calculation methods (CAD - 2D, 3D, CAE).

learning outcomes

Understanding the whole complex mechanical structures, the connection of individual parts and components, ability to design a functional and well-designed machines. The ability of practical application of modern software tools for designing in mechanical engineering. The capability to design, making good material and production methods selection of the most important parts of internal combustion engines. Selection and dimensioning of auxiliary systems and components needed for proper engine functioning.

theoretical teaching

The role of standardization and unification in the IC engine design. Phases of the classical approach to the design of the engine (sequential design). Definition of technical terms; Selection of the most important process and operating parameters in the construction of a new engine. Making of preliminary design and the main engine project. Preparation of workshop drawings. Testing and refinement of the prototype design; Simultaneous (parallel) design; Computer aided design; Technology of rapid prototyping; Mathematical modeling of working processes of Otto and Diesel-engine; Modeling of the fundamental elements of the Engine structure, the calculation by means of FEM.

practical teaching

Development of the project of the IC Engine - assembly drawings of the cross and longitudinal sections; 3D modeling (CAD) of one of the most important parts of the Engine and making workshop documentation for that part; Consultations in the preparation of the project.

prerequisite

Passed exams in Engine Working Processes and IC Engine Design 1.
Skills in using 2D & 3D CAD software

learning resources

- M. Cvetić: Extracts from lectures (handouts)
- 2D & 3D CAD CAE Software & Workstations

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 30
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 10
colloquium, with assessment: 0
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 60
final exam: 40
requirements to take the exam (number of points): 30

references

Basshuysen, R. von, Schaefer, F.: Internal Combustion Engine Handbook, SAE, Warrendale, 2004. ISBN 0-7680-1139-6.
Challen, B., Baranescu, R. (ed.): Diesel Engine Reference Book, 2nd Ed., Butterworth-Heinemann, Woburn, 1999. ISBN 0 7506 2176 1.
Mollenhauer, K., Tschoeke, H. (ed.): Handbook of Diesel Engines. Springer-Verlag, Berlin, Heidelberg, 2010. ISBN 978-3-540-89082-9.
Yamagata, H.: The science and technology of materials in automotive engines. Woodhead Publishing Limited, Cambridge, 2005. ISBN 1-85573-742-6.

Engine Working Processes

ID: MSc-0278
teaching professor: Томић В. Мирољуб
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: internal combustion engines

goals

The aims of the course are: Gaining basic theoretical and practical knowledge about physicality of real engine working processes. Making a complete spark ignition and diesel engine working cycle calculation. Analysis of engine working process integral working parameters and operating characteristics.

learning outcomes

Merging a theoretical knowledge of thermodynamics and fluid mechanics, connecting and application on real object – internal combustion engine.
Training for basic modeling and calculating of real engine working process, as well as acquiring fundamentals of engine designing.
Mastering of engine working parameters and operating characteristics and of the influences of working process on operating, energetic and ecologic engine characteristics.

theoretical teaching

1. Analysis of thermodynamic ideal cycles. Engine real working cycle; fundamentals of cycle modeling. 2. Gas exchange process; gas flow through the channels and valves. Gas exchange in 4-stroke engines; valve timing; indicators of gas exchange process quality. Gas exchange in 2-stroke engines. Compression process. 3. Combustion in spark ignition engine; phases, influencing factors and process calculation. 4. Combustion in diesel engine; phases, influencing factors and process calculation. Diesel engine types according to the method of mixture formation. Expansion process. 5. Engine integral working parameters: indicating parameters, mechanical losses and effective parameters. Analysis of engine fuel consumption and specific effective work (mean effective pressure). Engine energetic balance. 6. Engine operating characteristics: speed and load characteristics, propeller and universal characteristics.

practical teaching

1. Analysis of thermodynamic ideal cycles; numerical examples of engine ideal thermodynamic cycles. 2. Gas exchange process in 4-stoke engines. Numerical examples: evaluation of gas exchange specific work, coefficient of residual gases and volumetric efficiency. Display of various gas exchange systems and types of 2-stroke engines. 3. Display of various spark ignition engines combustion chambers and their comparison. Display of various diesel engines combustion chambers and their comparison. 4. Instruction for engine working process calculation. Example of spark ignition engine working process calculation. Example of diesel engine working process calculation. Examination of student's engine working process calculation report.

prerequisite

No prerequisites required.

learning resources

1. M. C. Živković: Engine theory, Faculty of Mechanical Engineering, Belgrade, 1982.
2. M. Tomić, S. Petrović: Internal combustion engines, Faculty of Mechanical Engineering, Belgrade, 2008.
3. S.Petrović, M.Tomić: Engine working processes- handouts, available in PDF format at the Department of IC engines.
4. Test bench for internal combustion engines testing, Department of IC engines
5. Measuring-data acquisition system National Instruments PXI-1042-RT8186/5401/6123/6229/4070/6602/8461 (APC)
6. National Instruments LabView 7.1 (PPO)

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 12
laboratory exercises: 0
calculation tasks: 5
seminar works: 0
project design: 9
consultations: 4
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 2
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 5
colloquium, with assessment: 0
test, with assessment: 3
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 15
laboratory exercises: 0
calculation tasks: 15
seminar works: 0
project design: 30
final exam: 40
requirements to take the exam (number of points): 30

references

1. Heywood J. B., Internal Combustion Engine Fundamentals, McGraw-Hill, Inc., 1988.
2. Djačenko N. H., Teorija dvigatelei vnutrennego sgorania – rabočie procesi, Mašinostroenie, Lenjingrad, 1974.
3. Orlin A. S., Kruglov M. G., i dr.,Teorija rabočih procesov poršnevih i kombinirovanih

material handling, constructios and logistics

Computer aided design in material handling practice

ID: MSc-0295
teaching professor: Петковић Д. Зоран
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: material handling, constructios and logistics

goals

Basic goals of this course are: 1) introduction to finite element method and applications in design of structures for material handling machines, 2) gaining the practical skills for 2D and 3D design and modeling of material handling machines

learning outcomes

Students gain the practical skills for idealization and analysis of structural systems and develop critical approach in design. Also, they get knowledge in common used software packages in design of material handling machines.

theoretical teaching

Introduction to finite element method. The FEM analysis process for beams and truss elements. Member stiffness matrix. Coordinate transformation. Master stiffness matrix. Force vector. Solving for displacements. Recovery of internal forces and stresses. Examples of finite element models of structures of material handling machines. Modeling of 3D truss systems. Modeling of structures with geometric variability. Modeling of cables, hydraulic jacks, sheaves, lever mechanisms. Data processing.

practical teaching

Matrix method for calculation of displacements, internal forces and stresses in 2D truss system with 5 nodes. Matrix method for calculation of displacement and internal forces at plane two beam-elements model. Modeling the characteristic structures for material handling machines, in finite element software (trusses, beams, frames, cranes). Preparation for input data. Modeling of lever mechanisms on examples of excavators, lift tables and mobile cranes. 3D modeling in given software of some parts of material handling machines. 3D modeling of wheel block assembly and sheave block assembly.

prerequisite

Necessary: Mathematics 1, Strenght of materials
Advisable: Fundamentals of steel structures.

learning resources

1. Zoran Petkovic: Metalne konstrukcije u masinogradnji 1, Faculty of Mechanica Engineering, Belgrade, 2005.
2. Handouts

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 0
laboratory exercises: 30
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 10
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 0
laboratory exercises: 60
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

Conveying and Material Handling Machines

ID: MSc-0308
teaching professor: Зрнић Ђ. Ненад
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: material handling, constructios and logistics

goals

The main goal of this course is to acquaint students with material handling machines and conveying machines, types and design solutions and principles of work. The goal is to introduce students to master the practical skills needed to perform the engineering profession, such as the main machine parameters, load analysis, selection of drive units and calculation of the capacity.

learning outcomes

Mastering the curriculum students obtain general abilities that can be applied in engineering practice: knowledge and understanding of the principles of material handling and conveying machines, selection of parameters, defining the load of support structure, selection and calculation of drive units and determine the capacity of machines in operation.

theoretical teaching

Determination of the transport capacity of material handling and conveying machines. Conveyors, belt conveyors, apron conveyors, flight conveyors, overhead conveyors, elevators, screw conveyors, oscillating conveyors, roller conveyors, gravity conveyors, hoppers, feeders and gates , ropeways, basic performances of machines, structural solutions, basic calculations. material handling machines with translator motion, bridge and gantry cranes, unloading bridges, container cranes, performances, operational principles, analysis of load, calculations. material handling machines with rotational motion, jib cranes, tower cranes, portal cranes in ports, performances, structures, mechanisms. Elevators and industrial trucks, forklifts, storage cranes.

practical teaching

Calculation of conveyors with belt pulling element, the contour calculation and selection of propulsion belt conveyors, calculation around conveyor sections, calculation of conveyors with chain pulling element, apron and flight conveyors, calculation of bucket elevators, roller conveyors, screw conveyors. Video presentations of modern design of material handling machines, analysis of the machine operation in system, automation of work.

prerequisite

The conditions are defined by the curriculum of the study program.

learning resources

1. Nenad Zrnic: Conveying and Material handling machines - Hanouts and written lectures, 2011, DVL.
2. Slobodan Tosic, Material handling equipment - Mechanization of transport, Mechanical Engineering, Belgrade, 1999, KDA.
3. Slobodan Tosic, D. Ostric: Cranes, Faculty of Mechanical Engineering, 2005, KDA.

4. Computers, Laboratory 516, ICT / CAH

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 15
laboratory exercises: 0
calculation tasks: 15
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 10
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 60
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

Cranes Design

ID: MSc-0139
teaching professor: Зрнић Ђ. Ненад
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: material handling, constructios and logistics

goals

The main objective of this course is to achieve competence of students to master the principles of cranes design and that is able to be incorporated into the cranes design process in the future engineering work. The goal is to master specific practical skills for the selection of drive units, calculation of support steel structures of cranes and to get the knowledge on the standards for calculation, as well as realization of technical documentations.

learning outcomes

Mastering the curriculum students obtain general abilities that can be applied in engineering practice: the demands that are placed to the designer, linking basic knowledge in the field of material handling machines and equipment, to master methods and procedures in cranes calculations, capacity of analyzing alternative solutions in the design process, developing skills in presentation of projects.

theoretical teaching

The basic principles of cranes design, trends in development, maintenance, transportation and crane installation, testing and registration of cranes, safety measures. Standards for calculation of support structures of cranes, trolley selection, sizing and calculation of trolley supporting structure and its drive. Calculation of support structure of bridge cranes, the selection of geometry of main girders and end carriages, proof of stress, proof of deformation, proof of dynamic stiffness, loads of main girder, proof of welded connections. Elastic stability of girder, local stability of plate, calculation of the connections of main girders and end carriages, calculation of end carriage, specificities in calculation of the single girder bridge cranes.

practical teaching

Realization of the project of double girder crane, selection of drive units, selection of geometry and calculation of support structures of trolley and crane, proof of elastic stability - buckling of plates, calculation of single girder bridge cranes. Computer exercises, calculation of supporting structure of bridge cranes by using FEM, with training in the use and application of specialized software package KRASTA (Cranes Statik, non-commercial academic version without restrictions concerning calculations), for static and dynamic analysis of supporting structures of material handling and conveying machines by using finite elements method.

prerequisite

The conditions are defined by the curriculum of the study program.

learning resources

1. Nenad Zrnic: handouts - Written lectures, 2011, DVL
2. Slobodan Tosic, D. Ostric: Cranes, Faculty of Mechanical Engineering, 2005, KDA.
3. KRASTA - Program for statical and modal analysis of spatial frames, MANUAL, DVL.

4. Computers, Laboratory 516, ICT / CAH
5. KRASTA software package - program for statical and modal analysis of spatial frames, BSB Kühne GmbH, ICT / CSP

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 0
laboratory exercises: 15
calculation tasks: 0
seminar works: 0
project design: 15
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 5
check and assessment of seminar works: 0
check and assessment of projects: 5
colloquium, with assessment: 0
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 0
laboratory exercises: 20
calculation tasks: 0
seminar works: 0
project design: 40
final exam: 30
requirements to take the exam (number of points): 35

references

Eco Design

ID: MSc-0127
teaching professor: Зрнић Ђ. Ненад
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: material handling, constructios and logistics

goals

The main objective of this course is to achieve competence and academic skills in the field of eco design and sustainable product development. The goal is mastery of the methodologies to define strategies to improve products and reduce the harmful effects of products on the environment, and understanding of the impact of products on the environment throughout its life cycle and innovative approach to obtaining environmentally improved products.

learning outcomes

Mastering the curriculum the student acquires the ability to master the strategies of eco-design for a more innovative environmental product improvement at the work on product development. Student masters the skills, tools and practical ability to obtain sustainable products, and acquire the ability to monitor environmental directives and communication with organizations that impose environmental requirements.

theoretical teaching

Introduction into Eco-design, basic concepts and terminology, the impact of products on the environment. Eco-Design strategy, product modeling, recommendations for the selection of materials with low impact on the environment, the impact of production technologies, transport and packaging, as well the phase of product use and product end-of-life on the ecological impacts. The assessment of product life cycle, methodology of environmental impact, practical examples. Environmental communication and the EU measures for environmental protection, directive, eco-labels and declarations. Application of Eco-Design for the improvement of existing products. Design for disposal and recycling of waste products, design for waste minimization, design for dismantling of old equipment.

practical teaching

Terminology of Eco Design. Examples of impacts of products on the environment. Examples of eco-design strategies. Examples of analysis of product life cycle in terms of Eco-Design. Examples of improvements of existing products. Examples of disposal and recycling of used goods. Eco Design computer tools, training and work in a computer tool EcoDesign Pilot + Assistant + EEG, obtaining an improved product through several stages which include the identification of products, Eco Design strategies and concrete measures for improvement.

prerequisite

The conditions are defined in curriculum of the study program.

learning resources

1. Nenad Zrnic: Ecodesign, Handouts - Written lectures, 2011, DVL.
2. Computers with Internet connection, Lab 455, ICT / CAH
3. EcoDesign Pilot software + + Assistant EEG, TU Wien, ICT / CSP

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 10
laboratory exercises: 15
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 5
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 4
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 6
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 40
laboratory exercises: 20
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

Ostad - ECODESIGN Sustainable Product Development, Vienna University of Technology, 2006, КСЈ.

Facility layout and industrial logistics

ID: MSc-0187
teaching professor: Косанић Ж. Ненад
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: material handling, constructios and logistics

goals

Introducing the students into the factories, factory facilities, transport and warehouse systems design process logic is the main goal. Development of the student system design creative and innovative abilities in order to increase the production, warehouse and logistic activities efficiency, contributing to the overall country industrial development is also the main issue.

learning outcomes

Student is introduced into design process logic and main mathematical models used in the production, transport, and warehouse systems modeling. Student is learn how to determine main system and subsystem performances representing the design solution efficiency or designer goals fulfillment degree.

theoretical teaching

Systematic design approach. Systems building. Feasibility studies. Design task. Main production programs. Production and technical production capacities. Factories subsystems and workshops. Technological project documentation. Design procedure. Production systems working regime. Working time fund. Production equipment needs estimation. Working space needs estimation. Working power needs estimation. Layout design. Flexible manufacturing systems definition, application fields and main characteristics. Layout design models. Material flow. Main logistic chain managing principles. Elementary subsystems (knot points) main characteristic. Queuing systems main foundations. Material flow analyzing models. Basic layout design inputs. Energy supply. Heating, ventilation and de-dusting. Master plan. Case studies and topics consulting.

practical teaching

Queuing model choosing for characteristic production and transport processes modeling. Computer calculation of queuing models statistics (outcome working parameters). Foundry concept study: Smeltery department production equipment needs estimation; Molding sand preparation department technology choosing and production equipment needs estimation; Core sand preparation department technology choosing and production equipment needs estimation;Mold cleaning department technology choosing and production equipment needs estimation; Foundry warehouse design; Some department crane or conveyer basic design parameters and capacity estimation; Foundry layout design; Foundry one department detailed layout design. Consulting and recommendations for factories, factory facilities, transport and logistic (warehouse-distributive) subsystems and systems modeling and designing.

prerequisite

Needed: Passed Subject: Mathematical probability and statistics, Material handling equipment, Fundamental of steel structures in heavy machinery.

learning resources

1, Dj. Zrnic, Facility layout design, Faculty of mechanical engineering, University of Belgrade, 1993.; 2, Dj. Zrnic, M. Prokic, P. Milovic, Foundry layout design, Faculty of mechanical engineering, University of Belgrade, 1998.; 3, Dj. Zrnic, D. Savic, Material flow simulation, Faculty of mechanical engineering, University of Belgrade, 1997.; 4, Dj. Zrnic, D. Petrovic, Facility layout design solved example problems, Faculty of mechanical engineering, University of Belgrade,, 1992.; 5, Queuing models software package, Faculty of mechanical engineering, University of Belgrade, 1999., lab, 459.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 20

active teaching (practical)

auditory exercises: 0
laboratory exercises: 3
calculation tasks: 0
seminar works: 0
project design: 35
consultations: 2
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 2
check and assessment of seminar works: 0
check and assessment of projects: 5
colloquium, with assessment: 3
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 30
laboratory exercises: 10
calculation tasks: 0
seminar works: 0
project design: 20
final exam: 30
requirements to take the exam (number of points): 35

references

Dj. Zrnic, Facility layout design, Faculty of mechanical engineering, University of Belgrade, 1993.
2, Dj. Zrnic, M. Prokic, P. Milovic, Foundry layout design, Faculty of mechanical engineering, University of Belgrade, 1998.
Dj. Zrnic, D. Savic, Material flow simulation, Faculty of mechanical engineering, University of Belgrade, 1997.
Dj. Zrnic, D. Petrovic, Facility layout design solved example problems, Faculty of mechanical engineering, University of Belgrade,, 1992.
Queuing models software package, Faculty of mechanical engineering, University of Belgrade, 1999., lab, 459.

Fundamentals of Mining and Construction Machines Dynamics

ID: MSc-0491
teaching professor: Бошњак М. Срђан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: material handling, constructios and logistics

goals

Basic course goals (objectives): 1) introducing students with specificities of dynamic processes of construction and mining machines . 2) mastering practical skills which are necessary for analysis of dynamic behavior of construction and mining machines.

learning outcomes

Mastering the curriculum student gains (acquires): 1) general skills which can be used in engineering practice (analysis, synthesis and anticipation of solution and consequences; development of critical approach) 2) specific skills (use of knowledge gain in fundamental academic fields on solving of concrete problems in field of construction and mining machines dynamics).

theoretical teaching

Fundamentals of basic excavating machines dynamics – backhoe excavators and bulldozers. Fundamentals of dynamics of raw material fragmenting and sorting machines – crushers and screening machines. Modeling of excitation of excavators for continuous excavation. Influence of design and work parameters on excitation caused by resistance to excavation. Modeling of bearing construction and mechanisms of excavators for continuous excavation. Identification and analysis of excavators for continuous excavation dynamic response on excitation caused by resistance to excavation. Vibrations caused by self-excitation. Dynamic response of bearing structure (construction) on excitation caused by wind. Dynamic of spreaders, mobile machines for continuous excavation (material handling).

practical teaching

Dynamic models of single bucket excavator excavating devices. Impact of Bulldozer to the obstacle. Calculation of basic parameters of crushing and screening machines. Bucket wheel excavators and trenchers excitation modeling (determination). Analysis of bucket wheel excavators bearing structure dynamic response on excitation caused by resistance to excavation Dynamic response of bearing structure (construction) on excitation caused by wind. Fundamentals of spreader dynamics. Consultations.

prerequisite

Required previously passed courses: Strength of Constructions, Structural and Stress Analysis, Mining and Construction Machines.

learning resources

1. Srđan Bošnjak, Bucket Wheel Trenchers, University of Belgrade, Faculty of Mechanical Engineering, Belgrade, 2001., 2. Srđan Bošnjak, Handouts, University of Belgrade, Faculty of Mechanical Engineering, Belgrade, 2008., 3. Srđan Bošnjak, Fundamentals of Mining and Construction Machines Dynamics, - Instructions for seminar paper realization, University of

Belgrade, Faculty of Mechanical Engineering, Belgrade, 2008., Computers, Laboratory 516, 5. Software Mathlab, (Catia)

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 20

active teaching (practical)

auditory exercises: 19
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 15
consultations: 5
discussion and workshop: 1
research: 0

knowledge checks

check and assessment of calculation tasks: 6
check and assessment of lab reports: 0
check and assessment of seminar works: 4
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 35
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 25
final exam: 30
requirements to take the exam (number of points): 35

references

J.P. Den Hartog, Mechanical Vibrations, McGraw-Hill Book Company, Inc., USA, 2007.

Mining and Construction Machines

ID: MSc-0102
teaching professor: Бошњак М. Срђан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: material handling, constructios and logistics

goals

Basic course goals (objectives): 1) introducing students with specificities of working process, design, modeling and calculation of basic (fundamental) subsystems of construction and mining machines and appliances, primarily machines for continuous excavation and machines for crushing and screening. 2) mastering practical skills which are necessary for design and calculation of construction and mining machines.

learning outcomes

Mastering the curriculum student gains (acquires): 1) general skills which can be used in engineering practice (analysis, synthesis and anticipation of solution and consequences; development of critical approach) 2) specific skills (use of knowledge gain in fundamental academic fields on solving of concrete problems in field of construction and mining machines).

theoretical teaching

Design solutions and calculations of slewing platforms and mechanisms of excavators. Design solutions and calculations of crawlers and walking mechanisms for excavator movement. Use, working process, structural scheme, drive and transmission systems and calculation of bucket wheel excavators and bucket chain excavators. Analytical and experimental methods of determination of static stability parameters. Theoretical fundaments of crushing process. Jaw, cone, roll and impact crushers – design, calculation. Theoretical fundaments of screening process. Static and dynamic screens - design, calculation.

practical teaching

Calculation of working (excavating) equipment, operating modes, and power of mechanisms of excavators for continuous excavation. 3D modeling of characteristic subassemblies of excavators for continuous excavation. Calculation models of truss substructures of bucket wheel excavators. Computer simulations of external loads. Load cases. Stress – strain identification. Creation (Development) of technical drawings. Position determination, selection and calculation of basic (main) parameters of stackers (spreaders). Calculation of basic technical (design) and technological parameters, power and strength of jaw and cone crushers and screens. Consultations.

prerequisite

Defined by the curriculum of the study program

learning resources

1. Srđan Bošnjak, Bucket Wheel Trenchers, University of Belgrade, Faculty of Mechanical Engineering, Belgrade, 2001., 2. Srđan Bošnjak, Handouts, University of Belgrade, Faculty of Mechanical Engineering, Belgrade, 2008., 3. Srđan Bošnjak, Mining and construction machines - Instructions for writing laboratory reports, University of Belgrade, Faculty of Mechanical

Engineering, Belgrade, 2008., Computers, Laboratory 459(516), 5. Software Mathlab, (Catia)

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 5
laboratory exercises: 20
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 5
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 5
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 5
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 30
laboratory exercises: 30
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

Vinko Jeftić, Construction and Mining Machines, University of Niš, Faculty of Mechanical Engineering, Niš, 1993.
Momir M. Plavšić, Construction Machines, Scientific Book, Belgrade, 1990.

Structural and stress analysis

ID: MSc-0173
teaching professor: Петковић Д. Зоран
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: material handling, constructios and logistics

goals

Basic goal of this course is introduction to principles in design and calculation of steel structures for wide range of material handling machines (mining machines, earthmoving machines, cableways and lifts). Also, goal is development of student creative skills for designing the light but safe structures, i.e. rational structures.

learning outcomes

Student expands the knowledge in structural analysis for material handling machines with emphasis on identification of specific load/stress cases which may lead to failures of structures.

theoretical teaching

Theory of elasticity (basics). Stress-strain relations. Torsion of solid and hollow circular section bars. Torsion in thin-walled closed section beams. Torsion in thin-walled open section beams. Shear flow distribution. Shear stress distribution. Shear centre. Warping. Warping constant. Equation for rotational angle. Representation of stresses.

practical teaching

Calculation of section properties for thin-walled open section beams: centre of gravity, first moment of area, second moment of area, torsional constant, warping constant. Determination of shear centre for various thin-walled open sections. Calculation of shear stress distribution and bending stress distribution at characteristic sections performed on several types of thin-walled open section simple beams and cantilevers under loads. Determination of shear centre for thin-walled sections with developed software package.

prerequisite

Necessary: Mathematics 1, Strenght of materials.
Advisable: Fundamentals of steel structures

learning resources

1. Zoran Petkovic: Metalne konstrukcije u masinogradnji 2, Faculty of Mechanical Engineering, Belgrade, 2005.
2. Handouts

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 20
laboratory exercises: 5
calculation tasks: 5
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 4
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 6
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 30
laboratory exercises: 5
calculation tasks: 25
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

Transport and logistic systems design

ID: MSc-0119
teaching professor: Косанић Ж. Ненад
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: material handling, constructios and logistics

goals

Introducing the students into the advanced transport, warehouse and logistic (warehouse-distributive) systems design process logic is the main goal. Development of the student system design creative and innovative abilities in order to increase the material flow, warehouse and logistic activities efficiency, contributing to the overall country industrial development is also the main issue.

learning outcomes

Student is introduced into design process logic and main mathematical models used in the transport, warehouse and logistic (warehouse-distributive)systems modeling. Student is learn how to determine main system and subsystem performances representing the design solution efficiency or designer goals fulfillment degree.

theoretical teaching

System, elementary subsystem and environment variables and performance variables of the flexible transport system (FTS). FTS elementary subsystems. "Power and free" system main design characteristic. Flexible monorail system main design characteristic. Rail automated vehicle system main design characteristic. Automated guided vehicle system (AGVS) main design characteristic. Required flexible transport systems vehicle fleet estimation. Warehouse and logistic (warehouse-distributive) systems fundamental design characteristics: goods receiving subsystem, main warehouse subsystem, order picking subsystem, goods dispatching subsystem. One dimensional non strategy and strategy order picking models. Two dimensional order picking models. Case studies (with pointing out most important design parameters). Exercises of lectures.

practical teaching

Exercises of order picking models. Concept design of conventional warehouses with different warehouse technologies, hay-bay warehouses with different automation level and logistic (warehouse-distributive) systems: Goods receiving and dispatching subsystems area estimation, goods receiving and dispatching subsystems technology choosing, main warehouse subsystem technology choosing and capacity estimation,order picking subsystem technology choosing and capacity estimation; Storage equipment technical specification; Required applied transport systems vehicle fleet estimation; System performance variable estimation; Storage system layout design; Warehouse and logistic systems design recommendation and consultation.

prerequisite

Needed: Passed Subject: Mathematical probability and statistics, Material handling equipment, Facility layout and industrial logistics.

learning resources

1, Dj. Zrnic, Facility layout design, Faculty of mechanical engineering, University of Belgrade, 1993.; 2, Dj. Zrnic, M. Prokic, P. Milovic, Foundry layout design, Faculty of mechanical engineering, University of Belgrade, 1998.; 3, Dj. Zrnic, D. Savic, Material flow simulation, Faculty of mechanical engineering, University of Belgrade, 1997.; 4, Dj. Zrnic, D. Petrovic, Facility layout design solved example problems, Faculty of mechanical engineering, University of Belgrade,, 1992.; 5, Queuing models software package, Faculty of mechanical engineering, University of Belgrade, 1999., lab, 459. 6. Lecture handouts.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 20

active teaching (practical)

auditory exercises: 0
laboratory exercises: 0
calculation tasks: 10
seminar works: 5
project design: 20
consultations: 5
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 2
check and assessment of projects: 3
colloquium, with assessment: 5
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 30
laboratory exercises: 0
calculation tasks: 0
seminar works: 10
project design: 20
final exam: 30
requirements to take the exam (number of points): 35

references

1, Dj. Zrnic, Facility layout design, Faculty of mechanical engineering, University of Belgrade, 1993.
2, Dj. Zrnic, M. Prokic, P. Milovic, Foundry layout design, Faculty of mechanical engineering, University of Belgrade, 1998.
3, Dj. Zrnic, D. Savic, Material flow simulation, Faculty of mechanical engineering, University of Belgrade, 1997.
4, Dj. Zrnic, D. Petrovic, Facility layout design solved example problems, Faculty of mechanical engineering, University of Belgrade,, 1992.
Lecture Handouts

ID: MSc-0480
teaching professor: Петковић Д. Зоран
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 1
final exam: seminar works
parent department: material handling, constructios and logistics

goals

The goal of course is to acquaint students with the resources, machines and devices in the field of machinery used in various industries, especially in industry, construction, mining, transport, tourism, energy, process engineering, service industries, etc.. As well as to introduce students with the basic technology of making steel tubes volume up to 500 mm.

learning outcomes

The successful completion of course students are introduced to: 1 Production processes in companies that produce or use the funds for machinery, 2 Intermittent and continuous internal transport, 3 Processes, maintenance of equipment and machinery for machinery, and others.

theoretical teaching

Introduction. Basics of the measures of safety and health at work when using the equipment and resources to work in general, and in machinery. The basic principles of machines and devices for machinery. Fundamentals of technological processes in industry to manufacture machinery and construction machinery in the area. Fundamentals of design of transport and logistics systems.

practical teaching

Organization of visits to factories and metal processing complexes where machines and devices in the field of machinery and construction are produced, as well as visits to industrial companies that use internal transport means which are also an integral part of production and technological processes, and organization of visits to factories that produce steel structures, and elements of steel and concrete structures, where students acquire the necessary knowledge in the fields of planning and organization of production processes, use of internal resources and transportation machinery, machine maintenance and internal transport machinery, transport vehicles to increase the capacity and the capacity of transport vehicles the impact on the efficiency of production processes, maintenance of transport vehicles and machinery for mechanization. Organization and visits to large industrial systems for electricity generation using machinery from the machine whose efficiency and reliability is directly dependent on the production process, where students acquire the necessary knowledge in the field of design capacity of transportation facilities, and proper maintenance. Analysis of production programs and the type of production in the considered enterprises. Analysis of influential factors on the design capacity of machine machinery. Overview and analysis methods represented in the planning and track maintenance machine machinery. The proposal to introduce new methods. The recording and analysis of traffic flows. Visits to companies organized according to the following production units: Construction machinery applied to high rise buildings - application of machine prekidnog transport; complex construction machinery in energy, mining machinery complex surface mine; Vertical transport lifts, cranes Vertical transport; Production of steel profiles.

prerequisite

No conditions

learning resources

Tosic, S.: Transport equipment - Machinery Transport, Belgrade, 1999., Ostric, D., Tosic, S.: Cranes, Belgrade, 2005, Petkovic, Z.: Metal Structures in Mechanical engineering, Belgrade, 1996., Bosnjak S .: Bucket wheel excavators, Belgrade, 2001., Zrnic, Đ., Prokic, M., Milovic, P.: design foundry, Belgrade.

number of hours

total number of hours: 46

active teaching (theoretical)

lectures: 0

active teaching (practical)

auditory exercises: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 0
final exam: 46

assessment of knowledge (maximum number of points - 100)

feedback during course study: 70
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 0

references

Tosic, S.: Transport equipment - Machinery Transport, Belgrade, 1999.
Ostric, D., Tosic, S.: Cranes, Belgrade, 2005
Petkovic, Z.: Metal Structures in Mechanical engineering, Belgrade, 1996.
Bosnjak S .: Bucket wheel excavators, Belgrade, 2001.
Zrnic, Đ., Prokic, M., Milovic, P.: design foundry, Belgrade.

mathematics

Probability and statistics

ID: MSc-0354
teaching professor: Аранђеловић Д. Иван
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: mathematics

goals

Introduction to techniques of probability theory, reliability theory, mathematical statistics and their most important application in technics. Introduction to techniques of regression analysis and stochastic modelling.

learning outcomes

Training students for usage of probability theory, reliability theory and mathematical statistics in solving technical problems, as well as development of the capabilities for its own modeling of nondeterministic systems.

theoretical teaching

Basic concepts of probability theory. Random events. Conditional probability of an event. Total probability formula. Bayes formula. Bernoulli's Formula and its approximations. Random variables. Central limit theorem. Regression. Mathematical statistics mission. Generally about estimation of distribution parameters. Estimating expected value and variance of a random variable. Methods for estimating distribution parameters. Confidence intervals. Statistical hypothesis testing. Least squares method. Reliability of technical systems. Nonparametric hypothesis testing. Analysis of variance. Planning of statistical experiment. Random numbers. Monte-Carlo method. Random variables modelling. Technical systems simulation.

practical teaching

Basic concepts of probability theory. Random events. Conditional probability of an event. Total probability formula. Bayes formula. Bernoulli's Formula and its approximations. Random variables. Central limit theorem. Regression. Mathematical statistics mission. Generally about estimation of distribution parameters. Estimating expected value and variance of a random variable. Methods for estimating distribution parameters. Confidence intervals. Statistical hypothesis testing. Least squares method. Reliability of technical systems. Nonparametric hypothesis testing. Analysis of variance. Planning of statistical experiment. Random numbers. Monte-Carlo method. Random variables modelling. Technical systems simulation.

prerequisite

No prerequisites.

learning resources

I. Aranđelović, Z. Mitović, V. Stojanović, Probability and Statistics, Zavod za udžbenike i nastavna sredstva, Beograd 2011.

I. Aranđelović, Theory of random events, Vedes, Beograd 2005.

S. Radojević, Z. Veljković, Statistical methods, electronic edition, Beograd 2003.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 10
laboratory exercises: 5
calculation tasks: 5
seminar works: 5
project design: 2
consultations: 3
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 3
check and assessment of lab reports: 2
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 5
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 30
laboratory exercises: 5
calculation tasks: 10
seminar works: 10
project design: 0
final exam: 40
requirements to take the exam (number of points): 21

references

V. Simonović: Introduction to theory of probability and mathematical statistics, Naučna knjiga, Beograd, 1995.
Z. A. Ivković: Theory of probability and mathematical statistics, Građevinska knjiga, Beograd, 1980.
S. Vukadinović: Elements of theory of probability and statistics, Beograd 1986.
B. Vidaković, D. Banjević, Probability and statistics, exercises , Beograd 1989.
M. Nenadović, Mathematical analysis of measurment dates, Beograd 1988.

Theory of complex functions

ID: MSc-0582
teaching professor: Аранђеловић Д. Иван
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: seminar works
parent department: mathematics

goals

Introduction to techniques of complex functions and their most important application in technics.

learning outcomes

Training students for usage of complex functions theory in solving technical problems.

theoretical teaching

Partial equations of first order and their systems. Complex numbers. Sequences and series of complex numbers. Complex functions of complex variable. Complex derivative. Harmonic functions. Holomorphic functions. Cauchy–Riemann equations. Elementary functions. Conformal map. Integration.
Cauchy's formula. Power series. Analitic functions. Residue theory. Integral transformations. Fourier series. Special functions. Applications in the hydrodynamics, thermodynamics, and electrical engineering.

practical teaching

Partial equations of first order and their systems. Complex numbers. Sequences and series of complex numbers. Complex functions of complex variable. Complex derivative. Harmonic functions. Holomorphic functions. Cauchy–Riemann equations. Elementary functions (Polynomial functions, Exponential functions, Trigonometric functions, Logarithmic functions, Inverse trigonometric functions). Conformal map. Integration.
Cauchy's formula. Power series. Analitic functions. Residue theory. Integral transformations. Fourier series. Special functions. Applications in the hydrodynamics, thermodynamics, and electrical engineering.

prerequisite

No prerequisites.

learning resources

1. I. Aranđelović, Theory of complex function, electronic edition, Belgrade 2011.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 10
laboratory exercises: 0
calculation tasks: 10
seminar works: 5
project design: 0
consultations: 5
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 2
check and assessment of lab reports: 0
check and assessment of seminar works: 3
check and assessment of projects: 0
colloquium, with assessment: 5
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 25
laboratory exercises: 0
calculation tasks: 15
seminar works: 15
project design: 0
final exam: 40
requirements to take the exam (number of points): 21

references

D.S. Mitrinović, Complex analysis, Belgrade 1991.
M. Jevtić, M. Mateljević, Analitic functions, Belgrade 1986.

mechanics

Analitical mechanics
Biomechanics of tissue and organs
Biomechanics of tissue and organs
Biomechatronic robotics
Biomedical Apparatus and Devices
Biomedical Apparatus and Devices
Continuum Mechanics
Design of Assistive Medical Devices
Dynamics of a system of rigid bodies
Dynamics of variable mass systems
Mechanics M
Mechanics of robots
Random Vibrations in Mechanical Systems
Software Engineering in Biomedicine
Student practice M - BME
Theory of anisotropic body
Theory of Mechanical Vibrations

Analitical mechanics

ID: MSc-0010
teaching professor: Јеремић М. Оливера
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 4
final exam: oral
parent department: mechanics

goals

-to provide students knowledge of the fundamental principles and methods in Analytical Mechanics
-to enable students to solve practical problems in Analytical Mechanics using acquired knowledge in Analytical Mechanics
-to prepare students to monitoring novelties in science and engineering

learning outcomes

-to enable students to master terms, methods and principles in Analytical Mechanics
-to enable students to relate the knowledge from Analytical Mechanics with knowledge in other scientific fields, to apply knowledge from Analytical Mechanics in analysis, synthesis and prediction of solutions and consequences of problems in science

theoretical teaching

Free and Constrained Systems of Particles. Constraints and their Classification. Constraints Removal Principle. Generalized Coordinates and Generalized Velocities. Real and Virtual Displacement. Virtual Work of a Force. Ideal Constraints. Kinetic Energy of Systemin Generalized Coordinates and generalized Velocities. Lagrange’s Equations of the First Kind. Lagrange’s Equations of the Second Kind and their Structure. Law of Change of Total Kinetic Energy and Energy Integral. Cyclic Integral and Cyclic Coordinates. Routh’s Equations. Whittaker’s Method. Generalized Momentum. Hamiltonian Variables. Hamiltonian Function for Scleronomic and Rheonomic Systems. Canonical Equations of Hamilton for Conservative and Nonconservative Systems. Canonical Equations for Cyclic Coordinates of Conservative Systems. Canonical Transformation. Hamilton-Jacobi Equation. Method of Separation of Variables. Fundamentals of Variational Calculus. Synchronous and Asynchronous Variations. Hamiltonian Action and Hamilton’s Principle. Second Form of Hamilton’s Principle. Lagrange’s Principle. Jacobi's Form of Least Action Principle.

practical teaching

Generalized Coordinates and Generalized Velocities. Real and Virtual Displacement. Lagrange’s Equations of the First Kind. Lagrange’s Equations of the Second Kind and their Structure. Law of Change of Total Kinetic Energy and Energy Integral. Routh’s Equations. Whittaker’s Method. Generalized Momentum. Hamiltonian Variables. Hamiltonian Function for Scleronomic and Rheonomic Systems. Canonical Equations of Hamilton for Conservative and Nonconservative Systems. Canonical Equations for Cyclic Coordinates of Conservative Systems. Method of Separation of Variables. Fundamentals of Variational Calculus. Hamiltonian Action and Hamilton’s Principle. Second Form of Hamilton’s Principle. Lagrange’s Principle. Jacobi's Form of Least Action Principle.

prerequisite

Passed Mechanics 1, Mechanics 2, Mechanics 3 and Mechanics M

learning resources

[1] Gantmaher, F., Lectures in Analytical Mechanics, English translation, Mir Publishers 1975. (handouts)

number of hours

total number of hours: 45

active teaching (theoretical)

lectures: 18

active teaching (practical)

auditory exercises: 18
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 4
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 60
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 40
requirements to take the exam (number of points): 30

references

Butenin, N. V., Introduction in Analytical Mechanics, Nauka, Moskva, 1971.

Biomechanics of tissue and organs

ID: MSc-0559
teaching professor: Лазаревић П. Михаило
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 4
final exam: oral
parent department: mechanics

goals

To introduce students to the application of fundamental principles and laws of biomechanics of tissues and organs in order to understand and study them. Establishment of appropriate biomechanical model of tissue and organs using modern theory of viscoelasticity, the possibility of simulations based on them in order to confirm the experimental data, the possibility of applying for the purposes of design and design basis of the same. It allows the potential cooperation with experts in medicine or work in specialized clinical institutions.

learning outcomes

Attending the course students acquire the ability to analyze the possibility of solving the current problems related to the biomechanical properties and characteristics of human tissues and organs with the use of scientific methods and procedures as well as computer technology and equipment. In addition, students can connect basic knowledge of mechanics, mathematics, physics, anatomy, physiology, biomechanics with application in the bioengineering of tissues and organs.

theoretical teaching

Introduction to the biomechanics of tissues /organs. Introduction to continuum mechanics, transport phenomena, the basics of biofluids. Basic assumptions of linear theory of elasticity (LTE). Modeling based on the theory LTE. Biomechanical properties of blood vessels: the arterial system, venous sistem. Vascular anatomy, ventricular geometry and hemodynamics. Dynamics of biomechanical heart model. Biomechanics of the lungs. Biomechanics of the nervous and lymphatic tissue.
The dynamic behavior of biological tissues / organs: the relaxation of stress, creep, hysteresis. Introduction to the theory of viscoelasticity (TV):
Kelvin-Voigt and Maxwell model. Basic assumptions of the theory of nonlinear elasticity - the finite elastic deformation. Nonlinear dynamic behavior of tissues / organs. Elements of cell rheology. Tolerance of tissue / organ to impact loads.
Injury of the organ / tissue - the biomechanical modeling them. Biomechanical engineering to prevent tissue trauma. Biomechanical aspects of the growth of tissues / organs. Engineering tissues and organs. History and perspectives of future development of artificial tissue/organ

practical teaching

Introductory examples of tensor analysis. Biomechanical properties of hard tissues such as tooth-and bone man. Biomechanical properties of soft connective tissues-such as muscle, the muscle fibers. Biological-tissue modeling using LTE. Examples: elastin, collagen, cartilage-props. Modeling the behavior of biological tissue using LTVE: for example lung tissue, blood vessels. Biomechanical models of the respiratory, nervous and lymphatic systems. Structure and function of pulmonary parenhina. Examples of dynamic behavior of biological tissues / organs: the stress relaxation, creep, hysteresis. The case of the dynamic behavior of the diaphragm. An illustrative example of the final elastic deformation. Examples povrde organs / tissues: head and spinal cord-biomechanical models of the same. Tolerance of organs / tissues to impact operećenja. The growth of tissues and organs - such as bones. Examples of artificial models of tissues /organs (body parts).

prerequisite

desirable courses: Fundamentals of biomedical engineering, Human anatomy and physiology, Biomechanics of the human locomotor system

learning resources

[1]Y. C.Fung,Biomechanics:Mechanical Properties of Living Tissues, Springer, Berlin,2000,(КСЈ)
[2]Писани изводи са предавања (handouts),
[3]М.Лазаревић, Биомеханика ткива и органа,(скрипта у припреми),2011
[4]Joseph D.Bronzino,«Tissue Engineering and Artificial Organs (The Biomedical Engineering Handbook),CRC Press,2006.(КСЈ)
[5]D.Schneck,J.Bronzino,Biomechanics principles and applications,CRC Press, New York,2003.(КСЈ)
[6]National Instruments-LABVIEW,(ЦСП)
[7]WWWinternetlaboratorije,MATLAB,

number of hours

total number of hours: 45

active teaching (theoretical)

lectures: 18

active teaching (practical)

auditory exercises: 6
laboratory exercises: 3
calculation tasks: 4
seminar works: 0
project design: 2
consultations: 2
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 2
check and assessment of lab reports: 0
check and assessment of seminar works: 1
check and assessment of projects: 1
colloquium, with assessment: 2
test, with assessment: 1
final exam: 3

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 45
laboratory exercises: 0
calculation tasks: 0
seminar works: 0

project design: 15
final exam: 30
requirements to take the exam (number of points): 35

references

S. Cowin, S. B.Doty,Tissue Mechanics, Springer Science+Business Media, LLC,2007
Ed. Joseph D. Bronzino,The Biomedical Engineering HandBook, Second Edition. Boca Raton: CRC Press LLC, 2000
M,Lai,D.Rubin,E.Crempl, Introduction to Continuum Mechanics,Pergamon Press,1993.
H.A. Barnes,J.E Hutton,K. Walters F. R. S, An Introduction to rheologyI,Elsevier Amsterdam ,1993
C. Oomens, M. Brekelmans, F. Baaijens,Biomechanics: Concepts and Computation,Cambridge University Press,,2009

Biomechanics of tissue and organs

ID: MSc-0185
teaching professor: Лазаревић П. Михаило
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: mechanics

goals

To introduce students to the application of fundamental principles and laws of biomechanics of tissues and organs in order to understand and study them. Establishment of appropriate biomechanical model of tissue and organs using modern theory of viscoelasticity, the possibility of simulations based on them in order to confirm the experimental data, the possibility of applying for the purposes of design and design basis of the same. It allows the potential cooperation with experts in medicine or work in specialized clinical institutions.

learning outcomes

Attending the course students acquire the ability to analyze the possibility of solving the current problems related to the biomechanical properties and characteristics of human tissues and organs with the use of scientific methods and procedures as well as computer technology and equipment. In addition, students can connect basic knowledge of mechanics, mathematics, physics, anatomy, physiology, biomechanics with application in the bioengineering of tissues and organs.

theoretical teaching

Introduction to the biomechanics of tissues /organs. Introduction to continuum mechanics, transport phenomena, the basics of biofluids. Basic assumptions of linear theory of elasticity (LTE). Modeling based on the theory LTE. Biomechanical properties of blood vessels: the arterial system, venous sistem. Vascular anatomy, ventricular geometry and hemodynamics. Dynamics of biomechanical heart model. Biomechanics of the lungs. Biomechanics of the nervous and lymphatic tissue.
The dynamic behavior of biological tissues / organs: the relaxation of stress, creep, hysteresis. Introduction to the theory of viscoelasticity (TV):
Kelvin-Voigt and Maxwell model. Basic assumptions of the theory of nonlinear elasticity - the finite elastic deformation. Nonlinear dynamic behavior of tissues / organs. Elements of cell rheology. Tolerance of tissue / organ to impact loads.
Injury of the organ / tissue - the biomechanical modeling them. Biomechanical engineering to prevent tissue trauma. Biomechanical aspects of the growth of tissues / organs. Engineering tissues and organs. History and perspectives of future development of artificial tissue/organ

practical teaching

Introductory examples of tensor analysis. Biomechanical properties of hard tissues such as tooth-and bone man. Biomechanical properties of soft connective tissues-such as muscle, the muscle fibers. Biological-tissue modeling using LTE. Examples: elastin, collagen, cartilage-props. Modeling the behavior of biological tissue using LTVE: for example lung tissue, blood vessels. Biomechanical models of the respiratory, nervous and lymphatic systems. Structure and function of pulmonary parenhina. Examples of dynamic behavior of biological tissues / organs: the stress relaxation, creep, hysteresis. The case of the dynamic behavior of the diaphragm. An illustrative example of the final elastic deformation. Examples povrde organs / tissues: head and spinal cord-biomechanical models of the same. Tolerance of organs / tissues to impact operećenja. The growth of tissues and organs - such as bones. Examples of artificial models of tissues /organs (body parts).

prerequisite

desirable courses: Fundamentals of biomedical engineering, Human anatomy and physiology, Biomechanics of the human locomotor system

learning resources

[1]Y. C.Fung,Biomechanics:Mechanical Properties of Living Tissues, Springer, Berlin,2000,(KCJ)
[2]Lazarević, M. Basics Biomechanics, (script in preparation),2011.
[3] Written abstracts from the lectures (Handouts)
[4]Joseph D.Bronzino,«Tissue Engineering and Artificial Organs (The Biomedical Engineering Handbook),CRC Press,2006.(KCJ)
[5]D.Schneck,J.Bronzino,Biomechanics principles and applications,CRC Press, New York,2003.(KCJ)
[6]National Instruments-LABVIEW,(ЦСП)
[7]WWWinternetlaboratories,MATLAB,(ЦСП)

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 10
laboratory exercises: 6
calculation tasks: 7
seminar works: 0
project design: 4
consultations: 3
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 4
colloquium, with assessment: 3
test, with assessment: 3
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 45
laboratory exercises: 0
calculation tasks: 0
seminar works: 0

project design: 15
final exam: 30
requirements to take the exam (number of points): 35

references

S. Cowin, S. B.Doty,Tissue Mechanics, Springer Science+Business Media, LLC,2007
Ed. Joseph D. Bronzino,The Biomedical Engineering HandBook, Second Edition. Boca Raton: CRC Press LLC, 2000
M,Lai,D.Rubin,E.Crempl, Introduction to Continuum Mechanics,Pergamon Press,1993.
H.A. Barnes, A Handbook of elementary rheologyI,The Institute of Non-Newtonian Fluid Mechanics, Dep. of Mathematics, Uni. of Wales Aberystwyth, 2000
C. Oomens, M. Brekelmans, F. Baaijens,Biomechanics: Concepts and Computation,Cambridge University Press,,2009

Biomechatronic robotics

ID: MSc-0666
teaching professor: Лазаревић П. Михаило
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: mechanics

goals

Introduce students to basic concepts of kinematics and dynamics of biomechatronic robotic systems (BRS) and solving them using modern theories Rodrigo transformation matrix theory and finite rotations. Determination of the (simulation) models BRS which are important in practical problems BRS. Introduce students to the problems of designing biomechatronic robotic devices in selected examples of modern devices that are in use. Also, enabling students to critically approach the problem, understand the biomechatronic design philosophy and define the most important biomedical and other variables that will determine the characteristics of the device that is designed.

learning outcomes

By attending this course student acquires the ability to analyze problems and synthesis solutions to the problem of kinematics,dynamics and control of biomechatronic robotic systems using scientific methods and procedures as well as computer technology and equipment. This enabled him to understand the basic principles of biomechatronic design as well as applying solutions to practical problems of biomechatronic robotic systems and monitoring and implementation of innovation in the development of new biomechatronic robotic systems.

theoretical teaching

Basic concepts, definition of biomechatronic robot system (BRS). Orthogonal transformation of coordinates,Rodriguez formula and the transformation matrix (MT), arbitrary and reference configuration of БRS.Kinematic characteristics of BRS. Velocity of gripper tip of RS. Direct and inverse kinematics/dynamics of BRS.
Differential equations (DIFE)of motion of BRS,other methods of forming (DIFE) of motion of BRS. Equations of motion of RS with Langrange multipliers.Basic concepts of control RS.
Types of biomechatronic robotics:biomimetic robot,bioinspired robot,biomedical robot
Biomedical robotics, robotics for orthopaedics/medical/visceral/musculoskeletal surgery.Rehabilitation robotics, robotics for stroke patients, wearable medical devices.Robotics for high-speed screening and analysis.Introduction to micro-robots and nano-robots.

practical teaching

Examples of determining the number of degrees of motion of the BRS; Calculation the transformation matrix(MT)- typical cases. Determination of kinematic characteristics of the robot segment (RSE). Solving the direct and inverse kinematic task of RS. Solving the direct and inverse dynamics task of the BRS. Examples of DIFE of RS simulation in MATLAB-GUI, MATHEMATICA environment, an example of simulation RS using Cyberbotics Webots package. Example of control of the RS-laboratory robot NeuroArm with 7 degrees of freedom in human-friendly environment.
Examples of tele and robot assisted surgery:haptic devices and remote feedback.

Exoskeleton robots for rehabilitation- examples of Neuro-Bike system,NEURARM, NEUROExos, HANDEXOS as well as self-ported devices.

prerequisite

desirable courses: Mechanics 1, Mechanics 2 Mechanics 3,Biomechanics of locomotor system

learning resources

1.Čović M. V. Lazarević, Mechanics of Robot, MF Belgrade,2009.(Book)
2.Lazarević M. Exercises in mechanics of robot, MF Belgrade,2006.(ZZD)
3.Wittenburg J., Dynamics of Systems of Rigid Bodies, Teubner, Stuttgart, 1977. (XJ)
4.Craig J., Introduction to Robotics, Mechanics and Control, Addison-Wesley, 1989.
5.Pons J.L,Wearable robots: biomechatronic exoskeletons, John Wiley & Sons,2008.
6.Written abstracts from the lectures (Handouts)
7.Cyberbotics Webots - software package
8.NeuroArm-laboratory robot with 7 degrees of freedom.
9.MATLAB,MATHEMATICA-mathematics software packages

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 10
laboratory exercises: 6
calculation tasks: 7
seminar works: 0
project design: 4
consultations: 3
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 4
colloquium, with assessment: 3
test, with assessment: 3
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 45
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 15

final exam: 30
requirements to take the exam (number of points): 35

references

Graham M. Booker,Introduction to Biomechatronics,Scitech Publ.2012
Yoseph Bar-Cohen,Biomimetics, Biologically Inspired Technologies,CRC Press Taylor & Francis Group,2006
Bronzino JD. The biomedical engineering handbook. Boca Raton, FL: CRC Press; 2000.
Bruno Siciliano, Lorenzo Sciavicco Luigi Villani, Giuseppe Oriolo Robotics -Modelling, Planning and Control, 2009 Springer-Verlag London Ltd.
Ahmed A. Shabana, Dynamics of Multibody Systems,Cambridge University Press The Edinburgh Building, Cambridge , UK,2005.

Biomedical Apparatus and Devices

ID: MSc-0526
teaching professor: Голубовић Ђ. Зоран
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: mechanics

goals

Introducing students with problems of biomedical apparatus and devices, on example of numerous devices of last generation which are frequently in use. Students are became able critically to approach to problem, and to define the most important biomedical and other measurements which can determine characteristics of device which should be constructed.

learning outcomes

With attending this course, student is introduced with theoretical consideration, detailed analysis of modern devices, their practical application. Students also make their own seminary papers/projects, in which they embrace previously acquired knowledge's of mathematics, physics, mechanics, and all for application of what is learned in engineering practice.

theoretical teaching

1. Introduction to biomedical apparatus and devices. Short history of development. Classification and oversight of biomedical apparatus and devices. Criteria s which BAD should accomplish according to GMP and GLP.
2. General about filtration. Mechanisms of filtration. Types of filters. Retention rate. Types of filtration processes. Classification of filtration processes. Integrity testing of membrane filters.
3. Principles of filter constructions. Filtration surface. Main elements of filter housings. Construction of membrane filters.
4. Principles of manufacture of sterile medical products. Systems for water treatment. Washing and sterilization. Preparation of parental products. GMP requirements. Machines and equipment for PP products. Machines for bottle filling. Sterilization treatment. Machines for sterilization and depirogenization.
5. Biomedical devices for maintenance of basic life functions. Apparatus for biomedical monitoring.
6. Roentgen devices. Principles of functioning. Construction. Usage.
7. Computerization tomography. Principles of functioning. Image acquisition. Construction. Usage.
8. Magnetic resonance. Physical principles. Construction. Usage.
9. Ultrasound apparatus. Principles of functioning. US methods. Construction. Probes. Usage.
10. Apparatus and devices for rehabilitation of upper and lower extremities. Elements of biomechanics of extremities. Determination of mass center. Determination of moment of inertia. Types of devices and application.

practical teaching

Visit to eminent institutions in which are used biomedical apparatus and devices for everyday work. Visit includes lectures, practical explanations, and introducing to technical documentation, constructive characteristics, operational using, practiced characteristics. Students have possibility to see apparatus for ultrasound measurements, MRI, PET and CT scanning devices, apparatus for membrane ultrafiltration - HEPA, ULPA ilters, devices for air conditioning, apparatus for sterilization,..

prerequisite

Mechanics 1, 2, 3, Biomedical instrumentation and equipment, Biomaterials 1, Tissue and organs biomechanics.

learning resources

Written material from lectures (handouts).

number of hours

total number of hours: 67

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 20
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 10
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 4
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 0
final exam: 3

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 50
project design: 0
final exam: 40
requirements to take the exam (number of points): 30

references

Biomedical Instrumentation: Technology and Applications (Hardcover), By R. S. Khandpur (Author), McGraw-Hill Professional; 1st edition 2004.
Introduction to Biomedical Engineering, By John Enderle, Susan M. Blanchard, Joseph Bronzino, Second Edition, Elsevier Academic Press, Academic Press Series in Biomedical Engineering, 2005.
Design of Biomedical Devices and Systems (Hardcover), By Paul King (Author), Richard C. Fries (Author), Publisher Marcel Dekker, 2003.

Biomedical Apparatus and Devices

ID: MSc-0571
teaching professor: Голубовић Ђ. Зоран
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: mechanics

goals

Introducing students with problems of biomedical apparatus and devices, on example of numerous devices of last generation which are frequently in use (CT, PET, NMR, ultrasound, systems for filtration,..). Students are became able critically to approach to problem, and to define the most important biomedical and other measurements which can determine characteristics of device which should be used and constructed.

learning outcomes

With attending this course, student is introduced with theoretical consideration, detailed analysis of modern devices, their practical application. Students also make their own seminary papers/projects, in which they embrace previously acquired knowledge's of mathematics, physics, mechanics, and all for application of what is learned in engineering practice.

theoretical teaching

1. Introduction to biomedical apparatus and devices. Short history of development. Classification and oversight of biomedical apparatus and devices. Criteria s which BAD should accomplish according to GMP and GLP.
2. General about filtration. Mechanisms of filtration. Types of filters. Retention rate. Types of filtration processes. Classification of filtration processes. Integrity testing of membrane filters.
3. Principles of filter constructions. Filtration surface. Main elements of filter housings. Construction of membrane filters.
4. Principles of manufacture of sterile medical products. Systems for water treatment. Washing and sterilization. Preparation of parental products. GMP requirements. Machines and equipment for PP products. Machines for bottle filling. Sterilization treatment. Machines for sterilization and depirogenization.
5. Biomedical devices for maintenance of basic life functions. Apparatus for biomedical monitoring.
6. Roentgen devices. Principles of functioning. Construction. Usage.
7. Computerization tomography. Principles of functioning. Image acquisition. Construction. Usage.
8. Magnetic resonance. Physical principles. Construction. Usage.
9. Ultrasound apparatus. Principles of functioning. US methods. Construction. Probes. Usage.
10. Apparatus and devices for rehabilitation of upper and lower extremities. Elements of biomechanics of extremities. Determination of mass center. Determination of moment of inertia. Types of devices and application.

practical teaching

Visit to eminent institutions in which are used biomedical apparatus and devices for everyday work. Visit includes lectures, practical explanations, and introducing to technical documentation, constructive characteristics, operational using, practiced data's. Students have possibility to see apparatus for ultrasound measurements, MRI, PET and CT scanning devices, apparatus for membrane ultrafiltration - HEPA, ULPA ilters, devices for air conditioning, apparatus for sterilization,..

prerequisite

Mechanics 1, 2, 3, Biomedical instrumentation and equipment, Biomaterials in medicine and dentistry, Tissue and organs biomechanics.

learning resources

Written material from lectures (handouts).

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 40

active teaching (practical)

auditory exercises: 20
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 8
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 4
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 0
final exam: 3

assessment of knowledge (maximum number of points - 100)

feedback during course study: 20
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 50
project design: 0
final exam: 30
requirements to take the exam (number of points): 40

references

Biomedical Instrumentation: Technology and Applications (Hardcover), By R. S. Khandpur (Author), McGraw-Hill Professional; 1st edition 2004.
Introduction to Biomedical Engineering, By John Enderle, Susan M. Blanchard, Joseph Bronzino, Second Edition, Elsevier Academic Press, Academic Press Series in Biomedical Engineering, 2005.
Design of Biomedical Devices and Systems (Hardcover), By Paul King (Author), Richard C. Fries (Author), Publisher Marcel Dekker, 2003.

Continuum Mechanics

ID: MSc-0008
teaching professor: Голубовић Ђ. Зоран
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: mechanics

goals

-to introduce students contemporary problems of Continuum Mechanics as the basis of separated area of Mechanics such as Theory of Elasticity, Thermoelasticity, Theory of Plasticity, Fluid Mechanics, Strength of Materials
-to introduce students to the specially mathematical methods which are constitutive parts of the Continuum Mechanics such as Tensor Calculus, Differential Geometry, Computational and Numerical Methods

learning outcomes

From theoretical point of view, Continuum Mechanics are dealing with mathematical models of real bodies. In that way it can be get to the exact formulation of corresponding physical laws of considered body behavior as reaction under mechanical, thermical, electromagnetical and chemical effects. This is important for application of reached knowledge in engineering practice.

theoretical teaching

Mathematical fundamentals. Basic elements of tensor calculations. The concept of the continuum media.
Deformation of continuum media. Strain measures. Infinitesimal deformation. Principle concepts in kinematics.
Material and spatial time derivatives. Velocity and acceleration. Tensor of deformation. Rate of change of velocity deformation. The invariants of rate of change of velocity deformation. The relations between tensor of deformation and rate of change of velocity deformation.
Basic principles of continuum mechanics. Transport theorem. Mass balance equation. Momentum balance equation. Balance of angular momentum. Energy balance. Entropy balance. Rheological models. Elasticity, plasticity, fluids. Elastic body. Theory of plastic yield. Ideal fluids. Linear theory of elasticity. Linear theory of thermoelasticity.

practical teaching

Tensor calculations. Material and spatial time derivatives. Velocity and acceleration. Tensor of deformation. Rate of change of velocity deformation. The invariants of rate of change of velocity deformation. The relations between tensor of deformation and rate of change of velocity deformation.
Basic principles of continuum mechanics. Transport theorem. Mass balance equation. Stress tensor. Stress vector and stress tensor. Stress invariants. Principal stresses. General balance law. Momentum balance equation. Balance of angular momentum. Energy balance. Entropy balance. Rheological models.
Elasticity, plasticity, fluids. Elastic body. Theory of plastic yield. Ideal fluids. Linear theory of elasticity. Linear theory of thermoelasticity.

prerequisite

Passed Mechanics 1, 2, 3, M, Mathematics 1, 2 and 3.
Desirable: Mechanics M.

learning resources

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 20

active teaching (practical)

auditory exercises: 40
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 10
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 60
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 40
requirements to take the exam (number of points): 30

references

Jarić, J., Continuum Mechanics, Gradjevinska knjiga, Beograd, 1984. 18.2.
Holzapfel, A.G., Nonlinear Solid Mechanics, John Wiley and Sons, 2001. 18.2.
Romano, A., Lancellota, R., Marasco, A., Continuum Mechanics using "Mathematica", Birghaeuser, 2006.
Gurtin, E. M, Fried, E., Anand, L., Cambridge, 2010.

Design of Assistive Medical Devices

ID: MSc-0160
teaching professor: Лазаревић П. Михаило
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: mechanics

goals

Introduce students to the problems of designing medical devices on the example of a number of modern devices that are in widespread use. Train students to critically approach the problem and define the most important biomedical and other sizes that will determine the characteristics of the device that is projected.

learning outcomes

Student masters the basics of designing medical devices, studying this subject. Theoretical considerations, a detailed analysis of modern devices of practical use and self-development project, to connect the previously acquired knowledge in mathematics, physics, mechanics, electrical engineering with electronics and automatic control, to implement the lessons learned in engineering practice.

theoretical teaching

The design of assistive medical devices, defining the specifications of assistive medical devices on the basis of biomedical measurement using statistical analysis. Introduction to the basics of the functioning of assistive medical devices and defining the basic problems of designing assistive medical devices, as following: a pacemaker, defibrillator, artificial lung, dialysis machine, apparatus for monitoring glucose levels, cochlear implants and other devices for the sense of hearing and vision, implants and dentures in dental implants in orthopedics, prosthetics and orthotics for the arms and legs, wheelchairs, neuro-controlled devices

practical teaching

Elaboration of detailed numerical examples and the following examples in designing assistive medical devices: pacemakers, defibrillators, artificial lung, dialysis machine, apparatus for monitoring glucose levels, cochlear implants and other devices for the sense of hearing and sense of vision. There will also be considered examples of implants and dentures in dental implants in orthopedics, prosthetics and orthotics for the hands and feet, wheelchairs, neuro-controlled devices. In consultation with their faculty stuff, each student will be required to develop the concept of working the assistive medical device as well as to project proposed assistive medical device

prerequisite

desirable:Mechanics,Biomechanics of human locomotor system,Biomechanics of tissue and organs,Fundamentals of biomedical eng.,Human anatomy/physiology

learning resources

[1]M.Lazarević,Design of Assistive Medical Devices,(script in preparation),2011
[2]Written abstracts from the lectures (Handouts)
[3]R.Khandpur,Biomedical Instrumentation:Technology and Applications,McGraw-

Hill,2004.(КСЈ)
[4]D.Prutchi, M. Norris,Design and Development of Medical Electronic Instrumentation:A Practical Perspective of the Design,Construction, and Test of Medical Devices,Wiley-Interscience, 2004.(КСЈ)
[5]P.King,R.Fries,Design of Biomedical Devices and Systems,Marcel Dekker, 2003.(КСЈ)
[6] M. Kutz,BIOMEDICAL ENGINEERING AND DESIGN HANDBOOK,McGrawHill,Vol.1,2,2009
[7]Ahmed A. Shabana,Computational Dynamics,John Wiley & Sons, Inc., 605 Third Avenue, New York, NY,2001

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 9
laboratory exercises: 5
calculation tasks: 8
seminar works: 3
project design: 0
consultations: 5
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 5
check and assessment of projects: 0
colloquium, with assessment: 4
test, with assessment: 1
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 40
laboratory exercises: 0
calculation tasks: 5
seminar works: 15
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

J. M. Justiniano, V. Gopalaswamy,Practical Design Control Implementation,CRC Press LLC, Boca Raton, Florida,2002
R. Fries,Reliable Design of Medical Devices,CRC Press Taylor & Francis Group,Boca Raton, Florida,2006
Yoseph Bar-Cohen,Biomimetics, Biologically Inspired Technologies,CRC Press Taylor & Francis Group,2006
Bronzino JD. The biomedical engineering handbook. Boca Raton, FL: CRC Press; 2000.
Thompson, S.G. , Neurorehabilitation Devices. McGraw Hill,2006

Dynamics of a system of rigid bodies

ID: MSc-0011
teaching professor: Лазаревић П. Михаило
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: mechanics

goals

To introduce students to basic concepts of system of rigid bodies,(SRB). It is possible to solve direct and inverse kinematics and dynamics task of (SRB) using the classical approach as well as modern theory of finite rotation and quaternions. Determination of the (simulation) models SRB-differential equations of motion SRB which are important in practical problems of dynamics of SRB.

learning outcomes

Attending the course students acquire the ability to analyze problems and synthesis solutions to the problem of rigid body dynamics system with the use of scientific methods and procedures as well as computer technology and equipment. Enabled him to connect basic knowledge of mechanics, mathematics, physics, the practical application of solving current problems of rigid body dynamics system.

theoretical teaching

Introduction to dynamics of system of rigid bodies (SRB). Fundamentals of kinematic chains.Orthogonal transformation of coordinates (OTC). Basic theory of finite rotations (FROT). FROT and spherical motion of rigid body. Quaternions. Hamilton-Rodriguez (HG) parameters. The transformation matrix in case of rotation in regard to (HG parameters and quaternions` notation), the application of the spherical motion SRB. Dynamics of spherical motion of the rigid body.The first integrals of differential equations (DIFE)of spherical motion of rigid body. Constraints of system, ideal and real constraints. The kinetic energy of the system of the rigid bodies.Metric tensor of system. Generalized forces and the principle of ideality RS- different cases -specially conservative case. The case of real constraints.
(DIFE) of motion of the RS in (contra)covariant form. DIFE of motion of RS given in the form of kinematic chain with the structure of topological three; DIFE of motion of RS given in the form of closed-kinematic chain.Additional equations of contraints. Optimal motion of system of rigid bodies. Variational approach.
Maximum-principle-application to real systems. Introduction to system dynamics of deformable bodies and basic concepts of contact mechanics.

practical teaching

Examples of determining the OTC. Determining the number of degrees of freedom for a given SRB. Application of Rodriguez matrix transformation-typical cases. An example of determining the configuration of a case of SRB-an industrial machine. Examples of application of the finite rotation and quaternions in spherical rigid body motion. Instances of the spherical rigid body motion-typical cases. Determination of the kinetic energy of the system of rigid bodies as well as the metric tensor of SRB. Application on a concrete example: a mechanical model of washing machines as SRB. An instance of the formation of (contravariant)covariant forms of motion given SRB with 4-6 degrees of freedom. Synthesis of optimal control SRB.

prerequisite

desirable courses: Mechanics 1, Mechanics 2 Mechanics 3,

learning resources

1.Wittenburg J.,Dynamics of Systems of Rigid Bodies,Teubner,Stuttgart,1977.(KSJ)
2.Čović M. V. Lazarević, Mechanics of Robot, MF Belgrade,2009.(Book)
3.Lazarević M. Exercises in mechanics of robot, MF Belgrade,2006.(ZZD)
4.Shabana A. Dynamics of Multibody Systems,2005.(KSJ)
5.Written abstracts from the lectures (Handouts)
6.Cyberbotics Webots - software package
7.Laboratory model of washing machine-4DOFs.
8.NeuroArm-laboratory robot-7 DOFs.
9.SimMechanics,GUI,(CSP)

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 10
laboratory exercises: 6
calculation tasks: 5
seminar works: 0
project design: 6
consultations: 3
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 4
colloquium, with assessment: 6
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 40
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 20
final exam: 40
requirements to take the exam (number of points): 30

references

Ahmed A. Shabana,Computational Dynamics,John Wiley & Sons, Inc., 605 Third Avenue, New York, NY,2001
Pfeiffer, F., Mechanical System Dynamics,Springer-Verlag Berlin Heidelberg,2008.
Coutinho, M., Dynamic Simulation of Multibody Systems, Birkäuser, 2001.
Schielen,W. ed., Multibody Systems Handbook, Springer-Verlag, Berlin, 1990
Roberson, R.E., Schwertassek, R., Dynamics of Multibody Systems, Springer-Verlag, Berlin, 1988.

Dynamics of variable mass systems

ID: MSc-0009
teaching professor: Јеремић М. Оливера
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 2
final exam: oral
parent department: mechanics

goals

-to provide students knowledge of the fundamental principles and methods in Dynamics of variable mass systems
-to enable students to solve practical problems in engineering using acquired knowledge in Dynamics of variable mass systems
-to prepare students to monitoring novelties in science and engineering

learning outcomes

-to enable students to master terms, methods and principles in Dynamics of variable mass systems
-to enable students to relate the knowledge from Dynamics of variable mass systems with knowledge in other scientific fields, to apply knowledge from Dynamics of variable mass systems in analysis, synthesis and prediction of solutions and consequences of problems in science

theoretical teaching

-motion of variable mass particles and variable mass systems which are affected by active forces, reactions of constraints, reactive forces caused by separation or merger, or simultaneous separation and merger of particles of mechanical objects of the observed system
-Meschersky equation
-Fundamntal laws of Dynamics of variable mass systems: Impulse-linear momentum theorem, Angular impulse-angular momentum theorem and Work-kinetic energy theorem
-differential equations of motion in generalized coordinates

practical teaching

-differential equation of motion of variable mass particle
-Meschersky equation
-Ciolkovsky's formula
-Law of change of mass
-motion if a particle at resistance area
-differential equation of motion of variable mass particle systems
-Impulse-linear momentum theorem
-Angular impulse-angular momentum theorem
-Work-kinetic energy theorem
-Lagrange equations of the second kind for variable mass systems

prerequisite

Passed Mechanics 1, Mechanics 2, Mechanics 3 and Mechanics M

learning resources

[1] Trivunac, J., Basic in Dynamics of Reactive Systems, Institut za prostornu tehniku, Beograd, 1968. 18.2. (handouts)

number of hours

total number of hours: 30

active teaching (theoretical)

lectures: 12

active teaching (practical)

auditory exercises: 12
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 1
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 60
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 40
requirements to take the exam (number of points): 30

references

Kosmodemljanskij, A., A., Course in Theoretical Mechanics, second part, Prosveta, Moskva, 1966. 18.2.
Trivunac, J., Basic in Dynamics of Reactive Systems, Institut za prostornu tehniku, Beograd, 1968. 18.2.

Mechanics M

ID: MSc-0004
teaching professor: Митровић С. Зоран
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: mechanics

goals

The aim of this course is that students learn the elements of the dynamics of the oscillatory motion of a particle, the dynamics of variable mass particle, advanced problems in kinematics of a particle, kinematics of a complex motion of a rigid body and mechanical system of rigid bodies as well as the dynamics of spherical and general rigid body motion, the approximate theory of gyroscope and the impact theory.

learning outcomes

By gaining knowledge in this course, students will be able to efficiently solve complex problems in kinematics and dynamics of particle and material system. This knowledge can allow students to attend classes in specialized courses that analyze the kinematic and dynamic problems.

theoretical teaching

Rectilinear oscillation (vibration) of a particle. Free and forced, damped and undamped oscillations of a particle. Decrement of oscillations. Tremors. Resonance. Dynamic amplification. Resonant diagrams. Dynamics of a variable mass particle. Kinematics of a particle in curvilinear coordinates. Kinematics of the general motion of a rigid body. Kinematics of the complex motion of a rigid body. Synthesis of motions of a rigid body. Introduction to the kinematics of rigid body systems. Dynamics of spherical and general body motion. Approximate theory of gyroscope. Gyroscopic torque. The basic impact theory. The impact coefficient. Theorems about the changes of linear and angular momentum during the impact.

practical teaching

Rectilinear oscillation (vibration) of a particle. Free and forced, damped and undamped oscillations of a particle. Decrement of oscillations. Tremors. Resonance. Dynamic amplification. Resonant diagrams. Dynamics of a variable mass particle. Kinematics of a particle in curvilinear coordinates. Kinematics of the general motion of a rigid body. Kinematics of the complex motion of a rigid body. Synthesis of motions of a rigid body. Introduction to the kinematics of rigid body systems. Dynamics of spherical and general body motion. Approximate theory of gyroscope. Gyroscopic torque. The basic impact theory. The impact coefficient. Theorems about the changes of linear and angular momentum during the impact.

prerequisite

Defined by the curriculum study of graduate studies program.

learning resources

[1] Pavišić, M., Golubović, Z., Mitrović, Z. Mechanics - Dynamics of mechanical systems,

Faculty of Mechanical Engineering, Belgrade, 2011.
[2] Vuković, J., Simonović, M., Obradović, A., Marković, S., Collections of examples for Dynamics, Faculty of Mechanical Engineering, Belgrade, 2007.
[3] Handouts

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 30
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 10
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 60
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 40
requirements to take the exam (number of points): 30

references

Djuric, S., Dynamics and theory of oscillations, MF Belgrade, 1987.
Rusov, L., Dynamics, Naučna knjiga, 1988.

Mechanics of robots

ID: MSc-0007
teaching professor: Лазаревић П. Михаило
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: mechanics

goals

Introduce students to basic concepts of kinematics and dynamics of robotic systems. It is possible to solve direct and inverse kinematics and dynamics of the robot system (RS) using modern theory based on Rodriguez transformation matrix as well as the theory of finite rotations. Determination (simulation) models of RS - i.e. differential equations of motion of the RS, which are important in practical problems of the RS.Practical simulations RS using Cyberbotics Webots software package and students work with laboratory robot NEUROARM.

learning outcomes

By attending this course student acquires the ability to analyze problems and synthesis solutions to the problem of kinematics and dynamics of robotic systems using scientific methods and procedures as well as computer technology and equipment. This enabled him applying solutions to practical problems of robotic systems as well as monitoring and implementation of innovation in the development of new robotic systems.

theoretical teaching

Basic concepts, definition of robot system (RS). Orthogonal transformation of coordinates.Rodriguez formula and the transformation matrix (MT), arbitrary and reference configuration of RS.Complex MT of coordinates. Position vectors that define the configuration of the RS, internal and external coordinates of RS. Velocity and acceleration of the center of inertia of an arbitrary robot segment(RSE). Angular velocity and angular acceleration of an arbitrary RSE. Velocity of gripper tip of RS. Direct and inverse kinematics of robot task-as well as singular cases. Constraints of RS. Momentum, angular momentum, kinetic energy of arbitrary robot segment of RS. Kinetic energy and the metric tensor of RS. Generalized forces and the principle of ideality RS-different cases. Differential equations (DIFE)of motion of RS. (DIFE) of motion of the RS in covariant form. Other methods of forming (DIFE) of motion of RS. DIFE of motion of RS given in the form of kinematic chain with the structure of topological three; DIFE of motion of RS given in the form of closed-kinematic chain. Additional equations of contraints. Constrained motion of robotic gripper. Equations of motion of RS with Langrange multipliers. Redundant RS. Basic concepts of control RS.

practical teaching

Examples of determining the number of degrees of motion of the RS; Calculation the transformation matrix(MT)- in case of Euler angles, and Hamilton-Rodriguez parameters; Determination of kinematic characteristics of the robot segment (RSE): angular velocity and angular acceleration RSE, velocity and acceleration of the observed point-RSE cases of Rezales and Euler angles.Application of Rodriguez transformation matrix, determine position vectors which define the configuration of the RS-in MATLAB environment. Kinematic characteristics of the i-th robot segment. Solving the direct and inverse kinematic task of RS. Determination of (planar) inertia tensor RSE, RS. Obtaining momentum and angular momentum, kinetic energy, the coefficient of the metric tensor RS, generalized forces, Christoffel symbols of the first kind. Solving the direct and inverse dynamics task of the RS. Examples of DIFE of RS simulation in

MATLAB-GUI, MATHEMATICA environment, an example of a redundant RS. An example of simulation RS using Cyberbotics Webots package. Example of control of the RS-laboratory robot NeuroArm with 7 degrees of freedom in the MATLAB environment.

prerequisite

desirable courses: Mechanics 1, Mechanics 2 Mechanics 3,

learning resources

1.Čović M. V. Lazarević, Mechanics of Robot, MF Belgrade,2009.(Book)
2.Lazarević M. Exercises in mechanics of robot, MF Belgrade,2006.(ZZD)
3.Wittenburg J., Dynamics of Systems of Rigid Bodies, Teubner, Stuttgart, 1977. (XJ)
4.Craig J., Introduction to Robotics, Mechanics and Control, Addison-Wesley, 1989.
5.Written abstracts from the lectures (Handouts)
6.Cyberbotics Webots - software package
7.NeuroArm-laboratory robot with 7 degrees of freedom.
8.MATLAB,MATHEMATICA-mathematics software packages

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 10
laboratory exercises: 6
calculation tasks: 5
seminar works: 0
project design: 6
consultations: 3
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 4
colloquium, with assessment: 6
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 40
laboratory exercises: 0
calculation tasks: 0

seminar works: 0
project design: 20
final exam: 40
requirements to take the exam (number of points): 30

references

Bruno Siciliano, Oussama Khatib, Springer Handbook of Robotics,Springer-Verlag Berlin Heidelberg 2008.
Thomas R. Kurfess.,Robotics and automation handbook,CRC Press LLC, Boca Raton, Florida,2005
Ahmed A. Shabana, Dynamics of Multibody Systems,Cambridge University Press The Edinburgh Building, Cambridge , UK,2005.
M.W. Spong, M. Vidyasagar: Robot Dynamics and Control (Wiley, New York 1989)
R. Paul: Robot Manipulators: Mathematics, Programming and Control (MIT Press, Cambridge 1982)

Random Vibrations in Mechanical Systems

ID: MSc-0729
teaching professor: Тришовић Р. Наташа
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: mechanics

goals

Introduce students with concepts and tools of vibrations in the presence of uncertainty.
Fundamental concepts of random variables and processes such as probability density, probability distribution, statistical moments, and auto-correlation function.
Fundamental tools, standard techniques from deterministic vibration analysis.
Issues which are relating to nonlinear random vibration, using statistical linearization techniques and Monte Carlo simulation.
The students will become adept in producing input/output relationships for randomly vibrating linear systems.

learning outcomes

The students will be familiarized with the theory of random vibrations of mechanical systems with the use of fundamental techniques such as statistical linearization and Monte Carlo simulation.

theoretical teaching

Introduction to Probability and random variables. Introduction to random processes.
Random vibrations of sdof systems. Random vibrations of mdof systems. Failure of randomly vibrating systems. Markov vector approach. Monte Carlo simulation approach. Probabilistic methods in earthquake engineering. Fatigue failure and Vibration energy flow models. Problem solving sessions.

Keywords: Classical definition, relative frequency definition, axiomatic definition, conditional probability; stochastic independence; total probability theorem; random variable; probability distribution; probability density function; discrete, continuous, and mixed random variables; Scalar random variables. Multi-dimensional random variables, scalar and vector random processes; Gaussian random process; stationarity and ergodicity; Fourier representation of Gaussian random process; differentiation and integration of random processes; mean-square convergence; harmonic steady state (HSS); resonance; impulse response; Stochastic steady state; Frequency domain input-output relations; natural coordinates; normal modes; orthogonality; vector random excitations; input-output relations in frequency domain; structures under differential support motions; Statistics; random sample; sampling distributions; simulation of Gaussian random processes; simulation of stochastic differential equations; Statistical linearization for simple and multy-degree of freedom systems with stationary response; problems covering scalar and vector random variables;

practical teaching

Introduction to Probability and random variables. Scalar random variables. Multi-dimensional random variables. Introduction to random processes. Random vibrations of sdof systems. Random vibrations of mdof systems. Failure of randomly vibrating systems. Markov vector approach. Monte Carlo simulation approach. Probabilistic methods in earthquake engineering. Fatigue failure and Vibration energy flow models. Problem solving sessions.

prerequisite

learning resources

Written lectures (handouts)

MATLAB software

Lazić, D., Ristanović, M.: An Introduction to MATLAB, Faculty of mechanical Engineering, Belgrade, 2005.

Gilat, A., MATLAB: An Introduction with aplications, John Wiley & Sons, 2005

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 20
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 10

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 10
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 60
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 40
requirements to take the exam (number of points): 30

references

John Brian Roberts, Pol D. Spanos, Random vibration and statistical linearization, John Wiley and Sons, 1999.
Stephen H. Crandall, William D. Mark, Random vibration in mechanical systems, Academic Press, 1963.
John Doughty Robson, An introduction to random vibration, Edinburgh University Press, 1964

Software Engineering in Biomedicine

ID: MSc-0579
teaching professor: Голубовић Ђ. Зоран
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 2
final exam: written
parent department: mechanics

goals

Introducing students with principles of constructioning sowtvares and informational systems. Showing specificities of constructioning sowtvares and informational systems in biomedicinie. Enabling students to define the requirements for the software in cooperation with doctors, define the processes for which software's are created, defining and designing a database for biomedical applications, defining of object model for biomedical software.

learning outcomes

Attending the course students acquire the ability to develop software's for medical devices, as well as the designing of information systems in medicine. During this course students will overcome software design tools, will learn design techniques, as well as specificities of medical software's and information systems.

theoretical teaching

Theoretical classes: Introduction to Software Engineering. The elements of modeling, model, diagram, metamodel, processes, notations and languages. Specificities of software's for medical devices. Specificities of the design of information systems in medicine. Specificities of designing the large information systems in medicine. Formulation of problems, defining of projects of developmental methodology. Creating the model of requires. Defining the participants in process of taking requests. Defining the types of requests. Recognition of the critical elements in requests. Risk management. Creating use cases. Creating of the scenarios, creating of the prototypes. Creating a models of medical procedures. Principles of designing databases. Defining the entities, attributes and relations. Creating a conceptual model. Defining the domain. Creating entities, attributes, relationships, associations. Creating a physical model of the conceptual. Database. Creating a physical model in the detail. Creating OOM, using UML. Showing UML diagrams. A more detailed examination of the diagram package, class diagrams, calibration diagrams, sequential diagrams. Introduction to basic design patterns objective oriented. Designing a GUI. Specificities of medical software and interfaces for communication with devices and software. (Doctors during operation, in mobile units, patients with disabilities, ...) How big are projected medical systems. The procedures in the design. Design and distribution of hardware resources. Design of organizational structure. Designing the distribution of instances of software's. Types of tests. Testing white and black boxes. Unit tests. Tools for creating HTML prototypes HTML, Access, Matematica, Matlab, etc. Examples of medical software.

practical teaching

Introduction to software design tool PowerDesigner.
Examples of medical software - a graphical interface.
Examples of medical software - system architecture.
Creating the requirement model.
Creating a medical procedures.
Creating databases.

Creates an object model.
Creating a graphical interface.
Creating a large system.

prerequisite

Necessary: Biomedical instrumentation and equipment, Signal processing.

learning resources

[1] Written material from the lectures (handouts) [2] PowerDesigner tool for making the softwares [3] Material for prarctice in electronic form

number of hours

total number of hours: 30

active teaching (theoretical)

lectures: 13

active teaching (practical)

auditory exercises: 5
laboratory exercises: 0
calculation tasks: 5
seminar works: 0
project design: 0
consultations: 2
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 2
colloquium, with assessment: 0
test, with assessment: 0
final exam: 3

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 40
seminar works: 0
project design: 0
final exam: 50
requirements to take the exam (number of points): 40

references

Bronziono, J.D.: The Biomedical Engineering, Handbook, CRC Press-EEE Press, Boca Raton, 1995.
Van Bemmel, Musen: Handbook of Medical Informatics, Springer, 1997.

Student practice M - BME

ID: MSc-0565
teaching professor: Голубовић Ђ. Зоран
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 1
final exam: seminar works
parent department: mechanics

goals

Practical experiences, and work in environment where student will realize his/her professional career.
Identifying the basic functions of the working system in the field of design, development and production, as well as the roles and tasks of mechanical engineering in such a working system.

learning outcomes

Students get practical experience in organization and functioning of the environment in which they will apply their knowledge in the future professional career.
Student identifies models of communication in multidisciplinary team and business information flows.
Student recognizes the basic processes in the design, manufacture, maintenance, in the context of his future professional competence.
Personal contacts will be establish the and connections that they will be able to use during their studying, or by entering into future employment.

theoretical teaching

practical teaching

Practical work embrace all the activities in the organizations where are done different activities connected with application of engineering in biomedicinie.
Choosing the thematic unit and organization is done in consultation with professor.
Student may do practical work in: manufacturing organizations, constructional and consulting organizations, organizations which are dealing with maintenance of machine equipment, and public utility companies and in some of the laboratories at Faculty of Mechanical Engineering.
The practice may also be made abroad.
During practice, students must keep a diary in which they write descriptions of the performed tasks, the conclusions and observations.
After finished practice students must make a report which they will justify to the subject teacher. The report is submitted in the form of the elaborate.

prerequisite

Done practice and written diary of the activities.

learning resources

Health institutions (Military Medical Academy, Clinical Center of Serbia, private clinics and health institutions), Nanolab 1 and 2, Faculty of Mechanical Engineering.

number of hours

total number of hours: 46

active teaching (theoretical)

lectures: 0

active teaching (practical)

auditory exercises: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 10
consultations: 11
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 0
final exam: 25

assessment of knowledge (maximum number of points - 100)

feedback during course study: 70
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

Catalogues and webistes of manufacturers of biomedical apparatus and devices.

Theory of anisotropic body

ID: MSc-0005
teaching professor: Радосављевић Љ. Велимир
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: mechanics

goals

learning outcomes

theoretical teaching

practical teaching

prerequisite

learning resources

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 15
laboratory exercises: 0
calculation tasks: 15
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 8
test, with assessment: 2
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 60
laboratory exercises: 0
calculation tasks: 0

seminar works: 0
project design: 0
final exam: 35
requirements to take the exam (number of points): 30

references

Theory of Mechanical Vibrations

ID: MSc-0037
teaching professor: Обрадовић М. Александар
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: mechanics

goals

It is necessary to enable the students to independently form and solve linear differential equations of motion of mechanical models of real objects oscillatory moving in different areas of mechanical engineering.

learning outcomes

A learning basic concepts and methods of linear theory of vibrations with an arbitrary finite number of degrees of freedom and elastic bodies with one-dimensional mass distribution, using appropriate computer tools.

theoretical teaching

Stability of equilibrium of the conservative system. Silvester's criteria. Linearization of the differential equations of motion. Vibration of the conservative system. Frequencies. The main mode shapes of vibration. Modal matrix. Conservative systems with special values of natural frequencies (eigenvalues). Vibration of the body on the beam supports. Damped vibration. Forced undamped vibration. Forced vibration. Resonance. Beating. Dynamic amplification factor. The dynamic absorber without damping. Linear oscillations of non-stationary system. Forced damped vibration of the system. Lateral vibration of string. Longitudinal vibration of prismatic bodies. Torsional vibration of the shaft with circular cross section. Lateral vibration of prismatic bodies.

practical teaching

Stability of equilibrium of the conservative system. Silvester's criteria. Linearization of the differential equations of motion. Vibration of the conservative system. Frequencies. The main mode shapes of vibration. Modal matrix. Conservative systems with special values of natural frequencies (eigenvalues). Vibration of the body on the beam supports. Damped vibration. Forced undamped vibration. Forced vibration. Resonance. Beating. Dynamic amplification factor. The dynamic absorber without damping. Linear oscillations of non-stationary system. Forced damped vibration of the system. Lateral vibration of string. Longitudinal vibration of prismatic bodies. Torsional vibration of the shaft with circular cross section. Lateral vibration of prismatic bodies.

prerequisite

None

learning resources

Vuković, J., Obradović,A., Linear vibrations theory of mechanical systems, Mašinski fakultet, Beograd, 2007.,

handouts

Ružić D., Čukić R., Dunjić M., Milovančević M., Anđelić N., Milošević-Mitić V.: Strength of Materials,Book 5, Tables, Mašinski Fakultet, Beograd 2007.

Lazić D., Ristanović M.: Introduction to MATLAB , Mašinski fakultet, Beograd 2005.

MATLAB software

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 24
laboratory exercises: 6
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 4
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 6
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 45
laboratory exercises: 15
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 40
requirements to take the exam (number of points): 30

references

Vuković, J., Obradović,A., Linear vibrations theory of mechanical systems, Mašinski fakultet, Beograd, 2007.
Vujanović B.: Theory of vibrations, Fakultet tehničkih nauka, Novi Sad 1995.
Kojić M., Mićunović M.: Theory of vibrations, Naučna knjiga, Beograd 1991.
Vujičić V.: Theory of vibrations, Naučna knjiga, Beograd 1977.
Rao S.S.: Mechanical vibrations, Addison-Wesley Publishing Company Inc., 1995.

motor vehicles

Automotive Friction Systems
Forensic Engineering
Intelligent vehicle systems
Practical Training 2 - Motor Vehicles
System Effectiveness
Systems Engineering
Vehicle body structure
Vehicle Design
Vehicle drive and running gears
Vehicle Maintenance
Vehicle Mechatronics
Vehicles and Environment
Vehicle Testing

Automotive Friction Systems

ID: MSc-0434
teaching professor: Дубока В. Чедомир
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: project design
parent department: motor vehicles

goals

Student acquires necessary theoretical and practical knowledge and becomes being able to make a selection or to design a corresponding vehicle friction system (main clutch, braking system, friction materials) both in the case of building a new vehicle type of any vehicle category or in the case of reconstruction, re-make or maintenance of an existing vehicle type. Student also acquires basic knowledge on tribology of friction systems as well as knowledge necessary for formal verification of a given friction mechanisms or material.

learning outcomes

General:
- analyze, synthesize, solution prediction, consequence estimation
- acquiring research methods, procedures and processes
- development of critical and self-critical approach and approach
- application of knowledge in practice
- professional ethics.

Subject - specific:
- acquiring knowledge in teaching area (T/A)
- knowing and understanding of T/A and profession
- resolution to T/A practical problems
- synergy of knowledge fro different T/A
- follow-up and application of professional novelties
- T/A knowledge application
- application of ICT in T/A

theoretical teaching

Theoretical tuition is composed of four blocks each of them containing four thematic units with an overall number of 4x5 = 20 lecturing hours, with 4 x 2,5 = 10 additional hours for working out on the teaching subjects and acquisition of new material.
Four basic theoretical tuition blocks contains a) Friction Systems backgrounds, (b) friction clutches, (c) braking systems, and (d) friction brakes.
Student acquires knowledge about performance, design and other properties of friction materials, friction clutches and brakes in addition to knowledge about braking systems for motor vehicles and their trailers irrespective of their kind, type and categories, with a particular emphasis on purpose based selection.

practical teaching

Within the practical teaching, a student works out detailed thematic evaluation of above mentioned four teaching units by means of listening exercises. Afterwards, he practically apply acquired knowledge working out on calculus assignments (5 hours) and two project assignments (2 x 10 hours) - one in the area of friction clutches and another one in the area of brakes and / or braking systems, based on the case study principle. Student is basically supposed to acquire minimal engineering knowledge from two main areas in the filed - calculus and design of vehicular friction systems. It means student is asked to be able to individually finds solutions to calculus assignments, while in addition to that he should be able to work out an an initial (idea) project and a beforehand project of a given mechanism and/or system.

prerequisite

B.Sc. diploma in automotive engineering. It is mandatory for a student having already passed exams “Vehicle design 1” and “Vehicle design”

learning resources

1. Class room
2. Other author book, КДА
3. Foreign language books, КСЈ
4. other literature type, ДВЛ
5. IT Hardware, ЦИХ, КИО
6. IT software, ЦСП, ССО

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 25

active teaching (practical)

auditory exercises: 10
laboratory exercises: 0
calculation tasks: 5
seminar works: 0
project design: 10
consultations: 5
discussion and workshop: 5
research: 0

knowledge checks

check and assessment of calculation tasks: 4
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 6
colloquium, with assessment: 0
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 10
laboratory exercises: 0
calculation tasks: 20
seminar works: 0
project design: 50
final exam: 10

requirements to take the exam (number of points): 60

references

Lecturing handouts
Written instructions for clutch calculus
Written instructions for braking system calculus
J. Todorovic: Braking of motor vehicles, ZUiNS, Belgrade, 1989
Internet, OEM documentation

Forensic Engineering

ID: MSc-0439
teaching professor: Дубока В. Чедомир
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: seminar works
parent department: motor vehicles

goals

Student is enabled to apply forensic engineering methods, particularly in the area of motor vehicles, which comprises analyses and reconstruction of road accidents, vehicle damage estimation and vehicle value estimation based on case study principles. Analogous methods will be applied in other filed of mechanical engineering, depending on the interest of students.

learning outcomes

General:
- analyze, synthesize, solution prediction, consequence estimation
- acquiring research methods, procedures and processes
- development of critical and self-critical approach and approach
- application of knowledge in practice
- professional ethics.
Subject - specific:
- acquiring knowledge in teaching area (T/A)
- knowing and understanding of T/A and profession
- resolution to T/A practical problems
- synergy of knowledge fro different T/A
- follow-up and application of professional novelties
- T/A knowledge application
- application of ICT in T/A

theoretical teaching

Organized in blocks.
First Block : general knowledge on forensics and forensic engineering, i.e. technical systems failure analyses, their causes and consequences, with a particular emphasis on the area of automotive engineering.
Second Block : Vehicle condition changes and value estimation methods
Third Block : Vehicle and component failures, i.e. accidents causing vehicle damage
Fourth Block : Vehicle damage estimation techniques and repair costs
Fifth Block : Analyses of road vehicle accident causes and consequences, with the elements of accident cite investigation and evidence collection, including accident reconstruction.

practical teaching

Organized in two forms, as listening exercises aiming at enable preparation for working-out on the case studies and in the form of seminar assignments within which each student will individually resolve the subject relevant cases on the bases of the case study methodologies. Student are provided with real data about vehicle (or other technical systems of interest) accidents, and they will study the causes and the consequences of such accidents or the causes of damage of these systems, in in particular they will analyses why an accident happen and what possibilities there are to avoiding it. A particular attention will be assigned to estimation of conditions under which such an accident might be generally avoided, but also in the particular case.

prerequisite

none

learning resources

1. Class room
2. Other author book
3. Foreign language books
4. Other literature
5. IT Hardware
6. IT software

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 10
laboratory exercises: 0
calculation tasks: 0
seminar works: 15
project design: 0
consultations: 5
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 10
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 75
project design: 0
final exam: 15
requirements to take the exam (number of points): 60

references

Lecturing handouts
Randall K. Noon, Forensic Engineering Investigation, CRC Press, 2001, ISBN 0-8493-0911-5
Wolfgang Hugemann, Unfall-rekonstruktion, Authoren Team GbR, 2007, ISBN 3-00-019419-3
R.M. Brach, R.M. Brach, Vehicle Accident Analysis and Reconstruction Methods, SAE Intl. ISBN 0-7680-0776-3, 2005
Internet

Intelligent vehicle systems

ID: MSc-0713
teaching professor: Александрић С. Драган
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: motor vehicles

goals

The goal of intelligent vehicles and accordingly intelligent vehicle systems is to augment vehicle autonomous driving either entirely or partly for the purposes of safety, comfortability, and saving energy. The tasks of intelligent vehicles become more challenging due to dynamic change of complex environment perception and necessity for sensing, modeling and prediction of different influencing factors on the vehicle performance. Autonomous intelligent vehicles have to perceiving and modeling environment in order to control the vehicles. The vehicle motion control faces the challenges of strong nonlinear characteristics due to high mass, especially in the processes of high speed and sudden steering/braking. It needs processing, modelling and prediction non-linear chnages in the vehicles system operation based on large amounts of data from multi-sensors and complex dynamic changes in an environment. Course objective is to provide an understanding the design and development process of intelligent vehicle systems and to develop students' skills and knowledge in the area of intelligent vehicle systems development.

learning outcomes

Course outcomes are development of student's abilities to: a) understand requirements being imposed to intelligent vehicle and its systems, assemblies, sub – assemblies, and parts, b) analyze the vehicle system operation and understand influences of the new intelligent solutions in the vehicle systems design on the vehicle overall performance and quality of use c) application of artificial intelligence techniques in development of intelligent solutions of the vehicle systems, d) analyze, understand and reconcile the new intelligent solutions in the vehicle system operation with legislation related to the specific vehicle systems and sub systems.

theoretical teaching

Theoretical lectures are divided into 7 sections:
1)Introduction – Intelligent vehicles and intelligent transport.
2)Monitoring and modeling of tire –road interaction.
3)Intelligent vehicle longitudinal control.
4)Intelligent vehicle lateral control.
5)Intelligent vehicle vertical control.
6)Intelligent vehicle vision systems.
7)Integrated intelligent control.

practical teaching

Students carry out a group-engineering project. Project is related to introduction of intelligent solutions in the given vehicle system operation. Students have to:
1)critical analyze the design solutions of the given vehicle system.
2)identify possibilities for introduction of the system intelligent abilities.
3)model and predict the system performance based on artificial intelligence techniques

4)test the system intelligent solutions.
5)compare conventional and introduced intelligent system performance.

prerequisite

There is no precondition.

learning resources

D. Aleksendrić, Intelligent vehicle systems, (hand-out), 2012.
D. Aleksendrić, V. Ćirović, Intelligent braking (book-in press), 2012.
Z. Miljković, D. Aleksendrić, Artificial neural networks-solved examples with theoretical background, Faculty of Mechanical Engineering University of Belgrade, 2009.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 10
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 20
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 5
colloquium, with assessment: 5
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 40
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 30
final exam: 20
requirements to take the exam (number of points): 30

references

H. Chneg: Autonomous intelligent vehicles - Theory, Algorithms, and Implementation , Springer 2011.
L. Li, F.-Y. Wang: Advanced Motion control and Sensing for Intelligent vehicles , Springer 2007.
R. Bishop: Intelligent vehicle technology and trends, © 2005 ARTECH HOUSE, INC.

Practical Training 2 - Motor Vehicles

ID: MSc-0452
teaching professor: Васић М. Бранко
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 1
final exam: seminar works
parent department: motor vehicles

goals

Course objective is to introduce students to manufacturing and technological processes and specific activities concerning vehicle development, production, exploitation, maintenance and revitalization.

learning outcomes

In real manufacturing conditions students acquire insight in whole process of vehicle and vehicle components production, exploitation, maintenance and revitalization according to course curriculum.

theoretical teaching

The course consists of auditory and laboratory exercises. Auditory exercises introduce students to practical training realization concept ant prepare them for all units of prescribed curriculum and way of communication. Guidelines for diary keeping and report writing are given and students record are created.

practical teaching

Laboratory exercises are conducted in laboratories of the Faculty of Mechanical engineering and also in laboratories outside the Faculty. Visits to manufacturing companies, companies involved in maintenance and vehicle dealers are organized according to curriculum and available resources.

prerequisite

Defined by study program/module curriculum.

learning resources

Guide for keeping a practice diary and writing final report. If practice is conducted in Motor Vehicle Department's laboratories all present equipment is available.

number of hours

total number of hours: 46

active teaching (theoretical)

lectures: 0

active teaching (practical)

auditory exercises: 0
laboratory exercises: 0

calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 0
final exam: 46

assessment of knowledge (maximum number of points - 100)

feedback during course study: 70
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

System Effectiveness

ID: MSc-0711
teaching professor: Васић М. Бранко
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: motor vehicles

goals

The objectives of the course are to provide a comprehensive insight into the issues (analysis and design) of system effectiveness, primarily in the areas of reliability and availability of technical systems (vehicles), maintenance, maintainability and life cycle. The course is intended for students of Motor Vehicles department, and it provides insight into the analysis and design of the effectiveness of the system (vehicle).

learning outcomes

Mastering the study program a student obtains general and subject-specific skills which are in a function of the contemporary approach to the analysis and design of technical systems (vehicles). The students acquire a basic ability to access the full access to today's analysis and design effectiveness (reliability, maintenance, maintainability), a perception of the life-cycle systems, and solving complex problems in this area.

theoretical teaching

Defining the requirements for effectiveness and reliability, maintenance and availability of system elements and system. The system. The basis of probability theory and its application in analysis, design reliability and maintenance. Definition of failure of the elements and system. Determination of empirical and theoretical characteristics of reliability of the elements of a system and of the systems (histogram, polygon, intensity of failure, the function of frequency, mean value, distribution laws (Weibull, normal, exponential, binomial, Poisson), tests of trust, confidence interval). Determination of reliability block diagrams of simple and complex systems (vehicles) - with the application of probability theory of complex events. Fault tree analysis, The analysis of mode, effect and criticality of faults, Integrated system approach. The general methodology of designing the vehicle and its parts from the point of application effectiveness, reliability and maintenance. Design of vehicle elements for a given level of reliability, relations of workload and critical load, the selection of intensity of failures for specific working conditions and environment. Laboratory testing of reliability.

practical teaching

The event-failure. Basics of probability theory and statistics. Determination of empirical and theoretical characteristics of reliability of the elements of a system and of the systems (histogram, polygon, intensity of failure, the function of frequency, mean value, distribution laws (Weibull). The compound probability. Reliability block diagram - connection of the elements in the system. Determining the function of system reliability (simple and complex). Design of reliability. Design based on work and critical loads. Allocation of reliability. Fault tree analysis, analysis methods, effects and criticality of failures.

1. Examples.
2. Examples - Independent work.
3. Seminar papers.
4. Exam.

prerequisite

No previous preconditions.

learning resources

1. J. Todorovic, D. Zelenovic: Effectiveness of the systems of mechanical engineering, Science book, Belgrade, 2010.
2. G. Ivanovic, D. Stanivukovic, I. Beker: The reliability of technical systems, Faculty of Mechanical Engineering, Belgrade, Faculty of Technical Sciences, Novi Sad, Serbian Army, 2010.
3. J. Todorovic: Engineering maintenance, Yugoslav Society of automotive engineers, Belgrade.
4. N. Vujanovic: The theory of reliability of technical systems.
5. G. Ivanovic: System Effectiveness, Faculty of Mechanical Engineering, Belgrade, Faculty of Technical Sciences, Novi Sad, 1978.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 16
laboratory exercises: 0
calculation tasks: 10
seminar works: 4
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 2
check and assessment of lab reports: 0
check and assessment of seminar works: 4
check and assessment of projects: 0
colloquium, with assessment: 4
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 30
seminar works: 30
project design: 0
final exam: 30
requirements to take the exam (number of points): 40

references

J. Todorovic, D. Zelenovic: Effectiveness of the systems of mechanical engineering, Science book, Belgrade, 2010.
G. Ivanovic, D. Stanivukovic, I. Beker: The reliability of technical systems, Faculty of Mechanical Engineering, Belgrade, Faculty of Technical Sciences, Novi Sad, Serbian Army, 2010.
N. Vujanovic: The theory of reliability of technical systems.
G. Ivanovic: System Effectiveness, Faculty of Mechanical Engineering, Belgrade, Faculty of Technical Sciences, Novi Sad, 1978.
Vasic, B. : Management and Engineering in Maintenance, IIPP, 2004.

Systems Engineering

ID: MSc-0451
teaching professor: Васић М. Бранко
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: motor vehicles

goals

Course objectives include the achievement of competencies and academic skills as well as methods for their acquisition, in the field of engineering systems. The goals arising from basic tasks and determine the specific results that should be realized within the subject and represent the basis for the control of the results achieved.

learning outcomes

Students obtain the following general ability:
- analysis, synthesis and forecasting of solutions and consequences
- mastering the methods, procedures and processes of research,
- application of acquired knowledge into practice.
Students acquire and subject-specific skills:
- thorough introduction to systems engineering,
- solving concrete problems by using scientific and engineering methods and procedures,
- development of the skills for the use of knowledge in the field of engineering systems.

theoretical teaching

Course content includes theoretical and practical classes. The entire course is divided into five blocks, of which the theoretical teaching consists out of four sessions with a total of 20 teaching hours per week, while the practical training part of the same four blocks are implemented with 15 hours of exercises and 15 hours of independent student work. For verification of the knowledge a total of 15 hours is provided, of which 10 for partial verification of the knowledge and 5 for the final test of knowledge. Five main teaching blocks include the following areas: (a) Introduction to systems (definitions, concepts, process), (b) The process of system design (preliminary and detailed design, development, testing and evaluation), (v) analysis of system and project evaluation (alternatives and models in decision making, models of economic evaluation, optimization techniques in the design of control), (g) designing for reliability, maintainability, usability (human factors), logistic support, and (d) management of engineering systems (program planning, organization, control).

practical teaching

Course content includes theoretical and practical classes. The entire course is divided into five blocks - auditory exercises follow the lectures. Practical teaching is done through 15 hours of exercises and 15 hours independent student work (computational tasks and seminar work). For verification of the knowledge a total of 15 hours is provided, of which 10 for partial verification of the knowledge and 5 for the final test of knowledge. Five main teaching blocks include the following areas: (a) Introduction to systems (definitions, concepts, process), (b) The process of system design (preliminary and detailed design, development, testing and evaluation), (v) analysis of system and project evaluation (alternatives and models in decision making, models of economic evaluation, optimization techniques in the design of control), (g) designing for reliability, maintainability, usability (human factors), logistic support, and (d) management of engineering systems (program planning, organization, control).

prerequisite

Defined by curriculum of module for motor vehicles.

learning resources

1. Vasic B., Todorovic J., et al.: Maintenance of Technical Systems, Institute for Research and Design in Commerce & Industry, Belgrade, 2006. (KPN)
2. Complete computer support for laboratory exercises.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 15
laboratory exercises: 0
calculation tasks: 5
seminar works: 10
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 3
check and assessment of lab reports: 0
check and assessment of seminar works: 7
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 25
seminar works: 35
project design: 0
final exam: 30
requirements to take the exam (number of points): 40

references

Vehicle body structure

ID: MSc-0441
teaching professor: Ракићевић Б. Бранислав
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: motor vehicles

goals

Aims of this course include achieving of competences to conquer specific knowledge and skills needed for overwiewing and understanding of problems related to construction, calculation, testing and verification of support structures of different categories of vehicles.

learning outcomes

By conquering of this course, students achieve general capabilities for conquering methods and procedures pointed to identification of vehicle support structures behaviour, which is assumption for optimization of constructive solutions. Also, students conquer a course-specific capabilities related to design and calculation of support structure for specified vehicle, according to actual regulations.

theoretical teaching

(1) Introduction; Constructive concepts of support structures (SS) in accordance to vehicle classification and categorization, characteristic solutions, basic instructions and recommendations. (2) Identification of SS behaviour, testing/calculation; methods, parameters and approval criteria; behaviour optimization, characteristic calculations modes. (3) Behaviour specificity of thin-walled open elements of SS. (4) Method of common constructive support surfaces, basic types of SS, ways and possibilities for implementation. (5) Finite elements method (FEM) in terms of methodological approach for behaviour identification of SS, basic characteristics and specificities. (6) Bus SS; specifities, strength of superstructures, domestic and international regulations. (7) Commercial vehicles SS; constructive and technological specificities of chassis of commercial vehicles, superstructures (different types, connection types for chassis and superstructure connecting, instructions and recommendations of chassis manufacturers), problems of vehicle completing (requests of valid standards and regulations, aspects of calculation, testing and verification). (8) Passenger vehicle SS; crush problems, values related to crushes, possibilities of modelling and experimental verification. (9) Regulations related to vehicle behaviour during crush (UN/ECE Regulations, EURO NCAP tests), characteristic parameters and criteria.

practical teaching

(1) Review of characteristic examples of passenger vehicles SS. (2) Review of specificities of SS for different bus categories (low-floor city bus, ..., high floor touristic bus, ...). (3) Review and comments of chassis examples for commercial vehicles, as well as instructions and recommendations of manufacturers for superstructure mounting. (4) Examples of implementation of analytical approach in chassis calculation (ladder-type chassis). (5) Review of problems in calculation using FEM for particularly characteristic examples. (6) Bus SS; valid regulations (UN/ECE Regulations), requests related to passive safety (UN/ECE Regulation R 66, review, comments and ways for fulfilling all requests). (7) Individual student thesis related to bus superstructures. (8) Commercial vehicles SS; valid regulations (UN/ECE Regulations), requests related to passive safety (UN/ECE Regulation R58, R73, ...). (9) Review of performing for some specific superstructures, explanations for different types of connections between

chassis and superstructure and their implementation in process of vehicle completing. (10) Comments for possibilites to special purpose vehicles realization and explanations for implementation of instructions and recommendations of chassis manufacturers; procedures for definning of relevant safety and technical characteristics of completed vehicles. (11) Individual student thesis related to special purpose commercial vehicles (different superstructures). (12) Passenger vehicles SS; regulations related to vehicle behaviour during crush (UN/ECE Regulations, EURO NCAP tests), comments related to characteristic examples

prerequisite

No specific terms.

learning resources

1. N. Janicijevic, D. Jankovic, J. Todorovic: Design of Motor Vehicles, Faculty of Mechanical Engineering, Belgrade, 2000,
2. D. Jankovic, N. Janicijevic: Coupling Road Vehicles and Special Devices: Theory – Design – Calculation – Standards, Faculty of Mechanical Engineering, Belgrade, 1985,
3. D. Jankovic, J. Todorovic, G. Ivanovic, B. Rakicevic: Theory of Vehicle Motion, Faculty of Mechanical Engineering, Belgrade, 2001,
4. Handouts,
5. Laboratory for Motor Vehicles, Institute for Motor Vehicles,
6. Laboratory CIAH, Institute for Motor Vehicles,
7. National and international standards, UN/ECE Regulations, EC Directives, related to motor vehicles
8. Technical documentation from leading world manufacturers (Volvo, Mercedes, Iveco, Renault, etc.) – Characteristics of vehicle chassis / guidlines and instructions for bodybuilders and vehicle completing,

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 15
laboratory exercises: 5
calculation tasks: 0
seminar works: 0
project design: 8
consultations: 2
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 6
colloquium, with assessment: 4
test, with assessment: 0

final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 30
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 30
final exam: 30
requirements to take the exam (number of points): 36

references

Tasko Maneski: Computer Modelling and structure calculation, Faculty of Mechanical Engineering, Belgrade, 1998
Julian Happian-Smith: An Introduction to Modern Vehicle Design, Butterworth-Heinemann, 2002
Dobrosav Ruzic: Strength of Constructions, Faculty of Mechanical Engineering, Belgrade, 1995
M. Huang, Vehicle Crash Mechanics, CRC Press, 2002.

Vehicle Design

ID: MSc-0437
teaching professor: Арсенић М. Живан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: motor vehicles

goals

Mastering the methods and techniques of vehicle design considering: (a) basic requests regarding whole vehicle and vehicle systems (b) characteristics of vehicle systems and their influence on quality of vehicle (duration and cost of development, testing, manufacturing and recycling) (c) regulations considering the variety of vehicle categories and vehicle systems categories

learning outcomes

Application of acquired knowledge in design of vehicles and vehicle systems, which implies knowledge of vehicle systems characteristics and their individual and synergetic effect on vehicle characteristics. Possibility to predict the impact of new solutions used in design of vehicle systems to usability of vehicle.

theoretical teaching

Theoretical course is divided into 16 sections: (1) historical development of automotive engineering (2) modern vehicle development (design, manufacturing and testing) (3) choosing the engine (4) clutch design (5) gearbox design (6) powertrain design (7) rear driveshaft design (8) final drive, differential and shafts design (9) choosing the wheels/tracks (10) chassis design (11) vehicle design considering crash resistance (12) ergonomic vehicle design (13) steering system design (14) suspension system design (15) braking system design (16) electronics and electronically controlled vehicle systems

practical teaching

Practical course is performed through student vehicle design project. Project is comprised of vehicle and vehicle systems design considering axle loads, wheelbase, center of gravity position and maximum vehicle speed. Vehicle systems that need to be designed for specified vehicle are: (1) engine(s) (2) clutch(es) (3) transmission (4) rear driveshaft (5) final drive and differential (6) driveshafts (7) wheels/tracks (8) chassis/frame (9) vehicle interior

prerequisite

Desirable: bacherol's degree (automotive engineer).

learning resources

1.N. Janićijević, D. Janković, J. Todorović: Vehicle Design (in Serbian), University of Belgrade - Faculty of Mechanical Engineering. 2. J. Todorović: Vehicle testing (in Serbian), JUMV, Belgrade, 1995. 3. J. Todorović: Vehicle braking (in Serbian), Serbian State Company of Textbooks, Belgrade, 1988. 4. Student vehicle design project instructions.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 5
laboratory exercises: 10
calculation tasks: 0
seminar works: 0
project design: 15
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 5
colloquium, with assessment: 5
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 0
laboratory exercises: 30
calculation tasks: 0
seminar works: 0
project design: 30
final exam: 30
requirements to take the exam (number of points): 35

references

Vehicle drive and running gears

ID: MSc-0440
teaching professor: Арсенић М. Живан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: motor vehicles

goals

Conquering of knowledge and skills for overviewing and understanding for problems related to motor vehicle design, calculation of vehice systems and components responsible for transmission, suspension and steering, and their influence on vehicle characteristics and behaviour.

learning outcomes

By conquring of this course, students achieve theoretical, experimental and practical knowledge and capabilities in means of methods and procedures for determination, estimation and improvement of certain vehicle systems characteristics, responsible for power transmission, as well as steering and suspension systems, which determine vehicle dynamic characteristics and behaviour.

theoretical teaching

(1) History of drive and running gear systems on vehicles; Characteristic examples and their specificities (2) Modern terms of motor vehicle and systems development (design, calculation, simulation, testing and production); (3) Design, calculation and testing of mechanical transmission systems and transfer cases; (4) Design, calculation and testing of driveshafts and driving axles (final drives, differentials, axle shafts); (5) Fuctional and constructive characteristics of vehicle running gears (steering and suspension systems and wheels), characteristic examples and their specificities; (6) Influence of running gears on longitudinal, sde and verticla dynamics of vehicles; (7) Kinematic and geometric characteristics of vehicle suspension systems and their influence on related forces distribution and vehicle behaviour; (8) Vehicle turning kinematics, cornering equations, estimation of steerability, influence factors.

practical teaching

Practic lessons include public and laboratory excercises. (1) Constructive concept of drive gear systems (sorts, ways of performing and application); (2) Constructive characteristics of drive gear systems (tasks, sorts, elements, assembling and disassembling, functionning on vehicle, etc.); (3) Practical examples related to design and calculation of certain transmission systems (at first gearboxes, drive shafts and drive axles); (4) Guidelines for students project related to design and calculation of particular transmission system in transmission chain using software support, as well as simulation of its operation process; (5) Constructive concept of running gear systems (sorts, ways of performing and application); (6) Constructive characteristics of running gear systems (tasks, sorts, elements, assembling and disassembling, functionning on vehicle, etc.); (7) Practical examples related to kinematic analysis of suspension system elements (graphic method and by computer); (8) Examples of defininig of kinematic and geometric characteristics of suspension systems and their influence on related forces distribution in wheel – surface contact; (9) Examples of vehicle turning kinematic analysis and distribution of side forces during turning and estimation of vehicle behaviour and stability.

prerequisite

Successfuly finished course of Vehicle Design. Also, it is preferable to have BSc degree for Motor Vehicles.

learning resources

1. N. Janjicijevic, D. Jankovic, J. Todorovic: Design of Motor Vehicles, Faculty of Mechanical Engineering, Belgrade, 2000, KDA.
2. Z. Arsenic: Computational Design of Transmissiona Systems, JUMV, Belgrade, 2003, KPN.
3. D. Jankovic., J. Todorovic, G.Ivanovic, B. Rakicevic: Theory of Vehicle Motion, Faculty of Mechanical Engineering, Belgrade, 2001 КПН
4. EOP, Laboratory for Vehicle Design, Institute for Motor Vehicles, LPS.
5. IKT, raspoloživo u laboratoriji za projektovanje vozila, CAD/CAE

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 15
laboratory exercises: 5
calculation tasks: 0
seminar works: 0
project design: 10
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 6
colloquium, with assessment: 4
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 30
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 30
final exam: 30
requirements to take the exam (number of points): 36

references

D. Bastow, G. Howard, J.P. Whitehead: Car Suspension and Handling, Professional Engineering Publishing, 2004
R.N. Jazar: Vehicle Dinamics Theory and Application, Springer, 2008
D. Karnopp, Vehicle Stability, CRC Press, 2004.

Vehicle Maintenance

ID: MSc-0435
teaching professor: Дубока В. Чедомир
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: project design
parent department: motor vehicles

goals

Student acquires relevant theoretical and practical knowledge about after sales activities of a vehicle manufacturer, and in particular concerning vehicle maintenance and the ways of establishing a system of authorized service organizations taking into consideration that without application of an appropriate maintenance system there will be no normal vehicle operation nor vehicle usage.
An automotive engineer must know how to make a vehicle, but also how to use and maintain it in order to enable its mission to be fulfilled in all usage conditions.
An automotive engineer must be educated and trained to design so called "Vehicle Maintenance System" i.e. to design programs and plan of preventive, corrective and combined maintenance as well as to design vehicle service technology and facilities in which it can be applied.

learning outcomes

General:
- analyze, synthesize, solution prediction, consequence estimation
- acquiring research methods, procedures and processes
- development of critical and self-critical approach and approach
- application of knowledge in practice
- professional ethics.

Subject - specific:
- acquiring knowledge in teaching area (T/A)
- knowing and understanding of T/A and profession
- resolution to T/A practical problems
- synergy of knowledge fro different T/A
- follow-up and application of professional novelties
- T/A knowledge application
- application of ICT in T/A

theoretical teaching

Theoretical tuition is composed of four blocks each of them containing four thematic units with an overall number of 4x5 = 20 lecturing hours, with 4 x 2,5 = 10 additional hours for working out on the teaching subjects and acquisition of new material.
Four basic theoretical tuition blocks contains (a)Maintenance - Life cycle, and investment effectiveness, Condition Time Sequence, Maintenance technological backgrounds, Variation of technological solutions, usage and maintenance in specific conditions, (b) Maintenance technologies (corrective, preventive, combined), Vehicle condition changes, Vehicle condition estimation methods, Technological procedures, (c) Project assignment, Number of vehicles to maintenance, Estimation of maintenance system capacity, Quality of Service, and (d) Kinds of maintenance technology processes, Maintenance Work place, Information systems, Logistics, Standardized and specialized service facilities.

practical teaching

In the practical tuition part student has 30 hours of individual work to work out a seminar work and a project.
In the practical tuition part, following the aforementioned four main blocks, student works out more detailed thematic evaluation within the listening exercises followed by an individual seminar assignment about designing maintenance system for a given vehicle and an individual project assignment about maintenance system for a given service facility based on the knowledge acquired within the third and the fourth block. Student will also work out on a assignment considering maintenance logistics support as an integral part of the maintenance system, will deal with the selection and choice of garage equipment for a given work place, and will also deal with the dimensioning of maintenance capacities, in addition to some basic elements concerning an information system about operation and service of vehicles, and maintenance system specification.

prerequisite

A B.Sc. diploma in automotive engineering is preference, and already passed exams in “Vehicle design 1” and “Vehicle design” are a must.

learning resources

1. Class room
2. Subject teacher's book, КДА
3. Subject teacher's book, КДА
4. other literature type, ДВЛ
5. IT Hardware, ЦИХ, КИО
6. IT software, ЦСП, ССО

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 10
laboratory exercises: 0
calculation tasks: 0
seminar works: 5
project design: 10
consultations: 3
discussion and workshop: 2
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 5
check and assessment of projects: 5
colloquium, with assessment: 0
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 20
project design: 60
final exam: 10
requirements to take the exam (number of points): 60

references

Lecturing handouts
Č. Duboka: Vehicle Maintenance Technology (in Serbian), Faculty of Mech. Engrg., Belgrade, 1992
Č. Duboka: Autoservices (in Serbian), JUMV, Belgrade, 1999, 2003, 2008
Internet, OEM and service documentation
Other

Vehicle Mechatronics

ID: MSc-0450
teaching professor: Васић М. Бранко
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: motor vehicles

goals

Course objectives are designed to meet the needs of the 21st Century automotive industry for graduates students with the necessary skills and understanding in mechatronics. Students should be able to deal with a wide range of activities that include researching, designing, developing, and testing of mechatronic systems in motor vehicles.

learning outcomes

Students obtain the following general ability:
- analysis, synthesis and forecasting of solutions and consequences
- mastering the methods, procedures and processes of research,
- application of the acquired knowledge into practice.

Students acquire and subject-specific skills:
- thorough introduction to the vehicle mechatronic systems,
- solving concrete problems by using scientific and engineering methods and procedures,
- development of the skills for the use of knowledge in the field of mechatronics in the vehicle.

theoretical teaching

The entire course is divided into four blocks, of which the theoretical classes consist of five thematic units with a total of 20 teaching hours per week, and from 10 teaching hours to work out learned materials and making examples. For verification of the knowledge a total of 15 hours is provided, of which 10 for partial verification of the knowledge and 5 for the final test of knowledge. The four main teaching blocks include the following areas: (a) Introduction to Mechatronics and basic mechatronic systems, (b) the vehicle mechatronic systems - general (control systems and automation, dynamics, sensors, micro-electronics, actuators, the central computer unit), (v) specific characteristics of mechatronic system of the vehicle (braking system, suspension system, power transmission systems, integrated systems of the vehicle) and (g) examples of design of mechatronic systems in vehicles.

practical teaching

a) Introduction to a project, b) Work on the project related to designed of given mechatronic system for the specified vehicle (defining functional characteristics, functional scheme of the system, assembly, sub-assembly, parts of the mechatronic system and their characteristics, simulation of operation of designed mechatronic system, introduction of intelligent abilities of the mechatronic system, defining of a testing procedure of the system's operation and defined functional goals, critical analysis of the project, conclusion derivation) c) Project presentation.

prerequisite

Defined by curriculum of module for motor vehicles.

learning resources

1. B. Vasic, V. Popovic: Vehicle Mechatronics (at prepress). (KPN)
2. Complete computer support for laboratory exercises. (EOP-LPS)
3. Z. Miljkovic, D. Aleksendric, Artifical Neural Networks - solved examples with theoretical background, Faculty of Mechanical Engineering University of Belgrade, 2009. (DVL)
4. D. Aleksendric, Vehicle Mechatornics, Handouts, 2010. (KPN)

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 10
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 20
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 5
colloquium, with assessment: 0
test, with assessment: 5
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 40
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 20
final exam: 30
requirements to take the exam (number of points): 30

references

W.Bolton: Mechatronics, Prentice Hall, London, 2008.

Vehicles and Environment

ID: MSc-0712
teaching professor: Поповић М. Владимир
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: motor vehicles

goals

The goal of this subject is to give the students an insight into effects vehicles have on the environment. Preservation of the environment and minimization of the negative impacts of driver-vehicle-environment system are the basis of modern vehicle development and exploitation. Therefore a more detailed analysis of these effects in this case are a prerequisite for creating a modern engineer, not only in the field of motor vehicles.

learning outcomes

By completing the planned activities students get to focus their engineering resources to modern trends of design and development of vehicles and their exploitation. These trends are largely based on global and local environmental requirements which are also a prerequisites of progress in this area in the modern world.

theoretical teaching

Introductory classes relate to the importance of the vehicle in production, transportation and traffic in contemporary economic and social environment.
They are followed by lectures that look back on the development of automotive technology that was largely affected by environmental conditions. The following lectures are divided into blocks according to a rough classification of basic elements of the impact of vehicles and drivers on the environment:
1. fuel consumption; 2. exhaust emission, 3. driver behaviour; 4. alternative fuels and hybrid vehicle drivetrain; 5. noise and vibration; 6. recycling and the use of modern materials in the vehicle.
The final lectures are planned to present the future trends in the design and exploitation of vehicles with the aim of improving environmental protection.

practical teaching

By conducting the practical training, students should identify and analyze the impact of the vehicle-driver-environment system on the environment, primarily through fuel consumption and exhaust emission. Through the laboratory classes, parameters of the vehicle engine for different driving modes (speed, acceleration and road conditions) are acquisited, providing the data for students to process in their reports and draw the conclusions. Students are also required to write the essay on a given subject.

prerequisite

Defined by motor vehicles module curriculum.

learning resources

Motor vehicle;
Vehicle and engine parameters data acquisition system.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 10
laboratory exercises: 5
calculation tasks: 0
seminar works: 10
project design: 0
consultations: 0
discussion and workshop: 0
research: 5

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 5
check and assessment of seminar works: 5
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 0
laboratory exercises: 30
calculation tasks: 0
seminar works: 30
project design: 0
final exam: 30
requirements to take the exam (number of points): 40

references

V. Popovic, Vehicle and Environment, Handouts, 2012. (DVL)
I. Blagojevic, Vehicle and Environment, Handouts, 2012. (DVL)

Vehicle Testing

ID: MSc-0436
teaching professor: Арсенић М. Живан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: motor vehicles

goals

Primary goal of this subject is to provide objective information about vehicle and vehicle assemblies and parts quality as well as exploitation conditions and loads, environmental impact, etc., in different phases of vehicle design, manufacturing and exploitation.

learning outcomes

1. Acquirement of theoretical-experimental knowledge in the field of vehicle testing. 2. Mastering the contemporary methods in the field of vehicle testing. 3. Training of students for testing of vehicle assemblies, parts and systems through practical examples in laboratory, field and exploitation testing.

theoretical teaching

Theoretical course is divided into five sections: 1. Basic concepts of vehicle testing, measuring equipment and data processing (basic definitions, measured quantities, types of tests, testing methodology, data processing and test reports) 2. Measuring of physical quantities using electrical measuring equipment (basic transducers and sensors characteristics, amplifiers, measuring bridges, accessories and display units) 3. Performance testing 4. Working load testing 5. Reliability testing.

practical teaching

Practical course contains three cycles of auditory and laboratory exercises: Cycle 1: Measurement of physical quantities using electrical measuring equipment (transducers and sensors application in practice) Cycle 2: Working loads testing (Testing of vehicle assemblies and systems in real exploitation conditions on test vehicle) Cycle 3: Reliability testing (testing of vehicle assemblies and systems reliability in laboratory on a test stands providing simulation of real exploitation conditions using specially developed methodology)

prerequisite

Compulsory subjects: Design of Vehicles

learning resources

Lectures in electronic form, practicum for auditory and laboratory exercises and instructions for writing test reports.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 8
laboratory exercises: 17
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 5
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 5
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 5
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 30
laboratory exercises: 30
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

naval systems

Buoyancy and Stability of Ship 2

ID: MSc-0189
teaching professor: Хофман М. Милан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: naval systems

goals

To cover the advanced knowledge of Naval Architecture connected to ship buoyancy and stability: ship loading, flooding, damaged ship stability and grounding. It is a continuation of the course Buoyancy and Stability of Ship 1.

learning outcomes

Ability to solve and analyze practical engineering tasks connected to ship loading/unloading, damaged ship stability and grounding. Practical knowledge of ship flooding calculations, according to international regulations.

theoretical teaching

Loading/unloading of cargo: centric loading (small and large cargo, liquid cargo), eccentric loading. Flooding: alternative methods (added weight or lost buoyancy), centric and eccentric flooding, flooding of compartments with solid and liquid cargo. Damaged ship calculations: deterministic and probabilistic calculations, curve of floodable length, regulations. Ship grounding: bottom reaction (small and large), grounded ship stability, critical reaction, docking. Methods for improving ship stability.

practical teaching

Practical problems of ship buoyancy and stability, illustrating the subjects lectured in theoretical syllabus. In addition, students have to accomplish individually the project: Flooding calculations (done in accordance to SOLAS regulations) for the ship already analyzed in projects of Buoyancy and Stability of Ship 1 (ship lines drawing, hydrostatic curves and intact stability calculations).

prerequisite

Semester 8 enrolled. Exam passed in Buoyancy and Stability of Ship 1.

learning resources

[1] Hofman, M.,: Extracts from lectures (handouts) /In Serbian/
[2] Ribar, B., The Theory of Ship, Faculty of Mechanical Engineering, 1987 /In Serbian/
[3] Bačkalov, I., Instructions for projects in buoyancy and stability of ship /In Serbian/.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 20
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 10
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 5
colloquium, with assessment: 5
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 15
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 25
final exam: 50
requirements to take the exam (number of points): 34

references

Biran, A., Ship Hydrostatics and Stability, Butterworth Heinemann 2003
K.J. Rawson & E.C. Tupper, Basic Ship Theory, Longmans 1967
Lewis, E.V., (editor): Principles of Naval Architecture, Part 1, SNAME 1987

Buoyancy and Stability of Ship 2

ID: MSc-0695
teaching professor: Бачкалов А. Игор
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: naval systems

goals

To cover the advanced knowledge of Naval Architecture connected to ship buoyancy and stability: ship loading, flooding, damaged ship stability and grounding. It is a continuation of the course Buoyancy and Stability of Ship 1.

learning outcomes

Ability to solve and analyze practical engineering tasks connected to ship loading/unloading, damaged ship stability and grounding. Practical knowledge of ship flooding calculations, according to international regulations.

theoretical teaching

Loading/unloading of cargo: centric loading (small and large cargo, liquid cargo), eccentric loading. Flooding: alternative methods (added weight or lost buoyancy), centric and eccentric flooding, flooding of compartments with solid and liquid cargo. Damaged ship calculations: deterministic and probabilistic calculations, curve of floodable length, regulations. Ship grounding: bottom reaction (small and large), grounded ship stability, critical reaction, docking. Methods for improving ship stability.

practical teaching

Practical problems of ship buoyancy and stability, illustrating the subjects lectured in theoretical syllabus. In addition, students have to accomplish individually the project: Flooding calculations (done in accordance to SOLAS regulations) for the ship already analyzed in projects of Buoyancy and Stability of Ship 1 (ship lines drawing, hydrostatic curves and intact stability calculations).

prerequisite

Semester 8 enrolled. Exam passed in Buoyancy and Stability of Ship 1.

learning resources

[1] Hofman, M.,: Extracts from lectures (handouts) /In Serbian/
[2] Ribar, B., The Theory of Ship, Faculty of Mechanical Engineering, 1987 /In Serbian/
[3] Bačkalov, I., Instructions for projects in buoyancy and stability of ship /In Serbian/.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 20
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 10
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 5
colloquium, with assessment: 5
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 15
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 25
final exam: 50
requirements to take the exam (number of points): 34

references

Biran, A., Ship Hydrostatics and Stability, Butterworth Heinemann 2003
Lewis, E.V., (editor): Principles of Naval Architecture, Part 1, SNAME 1987
K.J. Rawson & E.C. Tupper, Basic Ship Theory, Longmans 1967

International Maritime Regulations

ID: MSc-0385
teaching professor: Хофман М. Милан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: naval systems

goals

To cover the basic aspects of International Maritime Regulations, their evolution and development, and (especially) their influence on ship design. Critical analysis of the present regulations.

learning outcomes

Understanding of the basic concepts of maritime regulations, their development and their influence on ship safety, environment, and ship design.

theoretical teaching

Rules, regulations and conventions in design, construction and operation of ships. Types of regulations: prescriptive regulations, probabilistic regulations, goal-based standards. International maritime regulations: IMO Conventions; International Convention for Safety of Life at Sea (SOLAS). Tonnage Measurement – International Convention on Tonnage Measurement of Ships (Tonnage). Freeboard and load line regulations – International Convention on Load Lines (ICLL). Pollution from ships – International Convention for the Prevention of Pollution from Ships (MARPOL). International Convention for the Control and Management of Ships' Ballast Water and Sediments. Vibration and noise on ships. Regulations for construction of inland navigation vessels. European technical requirements for inland waterway vessels. Directive 2006/87/EC. ECE regulations. ADN regulations. National regulations. Impact of the regulations on ship safety, environment, and ship design. Critical analysis of the present regulations.

practical teaching

Practical examples and applications of the regulations covered by theoretical syllabus. Some detail of the regulations. Analysis of the impact of regulations on ship safety, environment, and ship design. The course is parallel to Ship Design, and the students implement the learned regulations to their individual projects.

prerequisite

Exams passed in Buoyancy and Stability of Ship 2, Ship Resistance, Ship Propulsion, Ship Structures 2.

learning resources

[1] Bačkalov, I., Extracts from lectures (handouts). /In Serbian/
[2] Maritime regulations: IMO Conventions (SOLAS, Tonnage, ICLL, MARPOL), etc.
[3] Technical requirements for inland vessels: ADN, ECE, Directive 2006/87/EC, etc

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 20
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 10
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 10
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 40
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 50
requirements to take the exam (number of points): 34

references

Kuo, Ch., Safety Management and Its Maritime Application, The Nautical Institute, 2007
Lamb, T., (editor): Ship Design and Construction, SNAME, 2003.
H. Schneekluth, V. Bertram: Ship Design for Efficiency and Economy, Butterworth-Heinemann, 1998.
Watson, D., Practical Ship Design, Elsevier, 1998.

International Maritime Regulations

ID: MSc-0494
teaching professor: Бачкалов А. Игор
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: naval systems

goals

To cover the basic aspects of International Maritime Regulations, their evolution and development, and (especially) their influence on ship design. Critical analysis of the present regulations.

learning outcomes

Understanding of the basic concepts of maritime regulations, their development and their influence on ship safety, environment, and ship design.

theoretical teaching

Rules, regulations and conventions in design, construction and operation of ships. Types of regulations: prescriptive regulations, probabilistic regulations, goal-based standards. International maritime regulations: IMO Conventions; International Convention for Safety of Life at Sea (SOLAS). Tonnage Measurement – International Convention on Tonnage Measurement of Ships (Tonnage). Freeboard and load line regulations – International Convention on Load Lines (ICLL). Pollution from ships – International Convention for the Prevention of Pollution from Ships (MARPOL). International Convention for the Control and Management of Ships' Ballast Water and Sediments. Vibration and noise on ships. Regulations for construction of inland navigation vessels. European technical requirements for inland waterway vessels. Directive 2006/87/EC. ECE regulations. ADN regulations. National regulations. Impact of the regulations on ship safety, environment, and ship design. Critical analysis of the present regulations.

practical teaching

Practical examples and applications of the regulations covered by theoretical syllabus. Some detail of the regulations. Analysis of the impact of regulations on ship safety, environment, and ship design. The course is parallel to Ship Design, and the students implement the learned regulations to their individual projects.

prerequisite

Exams passed in Buoyancy and Stability of Ship 2, Ship Resistance, Ship Propulsion, Ship Structures 2.

learning resources

[1] Bačkalov, I., Extracts from lectures (handouts). /In Serbian/
[2] Maritime regulations: IMO Conventions (SOLAS, Tonnage, ICLL, MARPOL), etc.
[3] Technical requirements for inland vessels: ADN, ECE, Directive 2006/87/EC, etc.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 20
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 10
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 10
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 40
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 50
requirements to take the exam (number of points): 34

references

Kuo, Ch., Safety Management and Its Maritime Application, The Nautical Institute, 2007
Lamb, T., (editor): Ship Design and Construction, SNAME, 2003.
H. Schneekluth, V. Bertram: Ship Design for Efficiency and Economy, Butterworth-Heinemann, 1998.
Watson, D., Practical Ship Design, Elsevier, 1998.

Seakeeping

ID: MSc-0697
teaching professor: Бачкалов А. Игор
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: naval systems

goals

To cover the basic knowledge of Naval Architecture connected to ship motion in waves (seakeeping).

learning outcomes

Knowledge in solving and analysis of practical engineering tasks connected to ship motion (roll, heave, pitch) in regular and irregular waves.

theoretical teaching

Ship motion in calm water: rolling, heaving and pitching. Ship's natural periods. Added mass and damping – strip theory, the Lewis forms. Waves at sea surface: hydrodynamic theory, stochastic theory. Ship motion in regular waves: rolling, heaving and pitching. Ship motion in irregular waves: motion spectra, mean, significant and RMS values of ship motion. Displacement, velocity and acceleration of ship points. Probability of deck wetness, propeller emergence and slamming. Added resistance. Effects on passengers and crew. Dynamic loads. Seakeeping criteria. Improvement of ship seakeeping characteristics. Roll stabilization.

practical teaching

Practical problems of seakeeping, illustrating the subjects lectured in theoretical syllabus. In addition, students have to accomplish individually the project on ship rolling, heaving and pitching in irregular waves, for the ship already analyzed in projects of Buoyancy and Stability of Ship.

prerequisite

Semester 9 enrolled. Exams passed in Buoyancy and Stability of Ship 1 and Buoyancy and Stability of Ship 2.

learning resources

[1] Milan Hofman: Extracts from lectures (handouts) /In Serbian/
[2] Milan Hofman: Seakeeping /To be published in Serbian/
[3] I. Bačkalov: Instructions for seakeeping project. /In Serbian/
[4] SEAWAY: Performance analysis of ships and offshore floating structures in waves.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 20
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 10
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 10
colloquium, with assessment: 0
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 40
final exam: 50
requirements to take the exam (number of points): 34

references

Lewis, Edward V. (editor), Principles of Naval Architecture, Part 3, SNAME 1987
A.R.J.M.LLoyd: Seakeeping - Ship Behaviour in Rough Weather
Lewandowski, E., The Dynamics of Marine Craft, World Scientific 2004.

Seakeeping

ID: MSc-0115
teaching professor: Хофман М. Милан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: naval systems

goals

To cover the basic knowledge of Naval Architecture connected to ship motion in waves (seakeeping).

learning outcomes

Knowledge in solving and analysis of practical engineering tasks connected to ship motion (roll, heave, pitch) in regular and irregular waves.

theoretical teaching

Ship motion in calm water: rolling, heaving and pitching. Ship's natural periods. Added mass and damping – strip theory, the Lewis forms. Waves at sea surface: hydrodynamic theory, stochastic theory. Ship motion in regular waves: rolling, heaving and pitching. Ship motion in irregular waves: motion spectra, mean, significant and RMS values of ship motion. Displacement, velocity and acceleration of ship points. Probability of deck wetness, propeller emergence and slamming. Added resistance. Effects on passengers and crew. Dynamic loads. Seakeeping criteria. Improvement of ship seakeeping characteristics. Roll stabilization.

practical teaching

Practical problems of seakeeping, illustrating the subjects lectured in theoretical syllabus. In addition, students have to accomplish individually the project on ship rolling, heaving and pitching in irregular waves, for the ship already analyzed in projects of Buoyancy and Stability of Ship.

prerequisite

Semester 9 enrolled. Exams passed in Buoyancy and Stability of Ship 1 and Buoyancy and Stability of Ship 2.

learning resources

[1] Milan Hofman: Extracts from lectures (handouts) /In Serbian/
[2] Milan Hofman: Seakeeping /To be published in Serbian/
[3] I. Bačkalov: Instructions for seakeeping project. /In Serbian/
[4] SEAWAY: Performance analysis of ships and offshore floating structures in waves.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 20
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 10
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 10
colloquium, with assessment: 0
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 40
final exam: 50
requirements to take the exam (number of points): 34

references

Lewis, Edward V. (editor), Principles of Naval Architecture, Part 3, SNAME 1987
Lloyd, A R J M, Seakeeping: Ship Behavior in Rough Weather, A R J M Lloyd 1998.
Lewandowski, E., The Dynamics of Marine Craft, World Scientific 2004.

Ship Design

ID: MSc-0696
teaching professor: Радојчић В. Дејан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: naval systems

goals

To integrate the knowledge acquired from previous courses of naval architecture, and to develop knowledge and skills for the basic ship design.

learning outcomes

Ability to develop ship design, with the corresponding calculations, plans and technical documentation, for various ship types.

theoretical teaching

Basic principles of ship design: The design spiral. Weight, volume and area-based design. Weight groups. Statistic data on existing ships. Statistic data and prototype-based design. Statistics-based ship design: Formulae for main dimensions and their interrelations, ship-form coefficients, weight groups, centre of mass, power prediction. Effects of ship's dimensions and ship form on stability, resistance, strength, maneuvering and seakeeping. Ship calculations in the first approximation. Ship calculations in the second approximation. Design based on prototype: The choice of the prototype. Main dimensions, form coefficients, weight groups, centre of mass, power prediction. Lines drawing. General arrangement plan. Other technical documentation. Specifics in cargo ships design (multipurpose ships, container ships, bulk carriers, tankers), passenger ships, naval ship etc. Specifics in inland vessels design.

practical teaching

Practical problems of ship design, illustrating the subjects lectured in theoretical syllabus. In addition, students have to develop individually the project of a cargo ship (preliminary ship design of a container ship, bulk carrier, multipurpose ship or a tanker), with all the necessary calculations, plans (including the general arrangement) and the technical documentation.

prerequisite

Exams passed in Buoyancy and Stability of Ship 2, Ship Resistance, Ship Propulsion, Ship Structures 2.

learning resources

[1] I. Bačkalov: Extracts from lectures (handouts). /In Serbian/
[2] I. Bačkalov: Instructions for project design. /In Serbian/
[3] Technical documentation of designed ships.
[4] The German Merchant Fleet, Seehafen Verlag, 2006
[5] Significant Ships, RINA Journals.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 5
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 25
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 10
colloquium, with assessment: 0
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 40
final exam: 50
requirements to take the exam (number of points): 34

references

Watson, D., Practical Ship Design, Elsevier, 1998.
H. Schneekluth, V. Bertram: Ship Design for Efficiency and Economy, Butterworth-Heinemann, 1998.
Lamb, T., (editor): Ship Design and Construction, SNAME, 2003.

Ship Design

ID: MSc-0106
teaching professor: Хофман М. Милан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: naval systems

goals

To integrate the knowledge acquired from previous courses of naval architecture, and to develop knowledge and skills for the basic ship design.

learning outcomes

Ability to develop ship design, with the corresponding calculations, plans and technical documentation, for various ship types.

theoretical teaching

Basic principles of ship design: The design spiral. Weight, volume and area-based design. Weight groups. Statistic data on existing ships. Statistic data and prototype-based design. Statistics-based ship design: Formulae for main dimensions and their interrelations, ship-form coefficients, weight groups, centre of mass, power prediction. Effects of ship's dimensions and ship form on stability, resistance, strength, maneuvering and seakeeping. Ship calculations in the first approximation. Ship calculations in the second approximation. Design based on prototype: The choice of the prototype. Main dimensions, form coefficients, weight groups, centre of mass, power prediction. Lines drawing. General arrangement plan. Other technical documentation. Specifics in cargo ships design (multipurpose ships, container ships, bulk carriers, tankers), passenger ships, naval ship etc. Specifics in inland vessels design.

practical teaching

Practical problems of ship design, illustrating the subjects lectured in theoretical syllabus. In addition, students have to develop individually the project of a cargo ship (preliminary ship design of a container ship, bulk carrier, multipurpose ship or a tanker), with all the necessary calculations, plans (including the general arrangement) and the technical documentation.

prerequisite

Exams passed in Buoyancy and Stability of Ship 2, Ship Resistance, Ship Propulsion, Ship Structures 2.

learning resources

[1] I. Bačkalov: Extracts from lectures (handouts). /In Serbian/
[2] I. Bačkalov: Instructions for project design. /In Serbian/
[3] Technical documentation of designed ships.
[4] The German Merchant Fleet, Seehafen Verlag, 2006
[5] Significant Ships, RINA Journals.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 5
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 25
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 10
colloquium, with assessment: 0
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 40
final exam: 50
requirements to take the exam (number of points): 34

references

Watson, D., Practical Ship Design, Elsevier, 1998.
H. Schneekluth, V. Bertram: Ship Design for Efficiency and Economy, Butterworth-Heinemann, 1998.
Lamb, T., (editor): Ship Design and Construction, SNAME, 2003.

Ship Maneuvering

ID: MSc-0143
teaching professor: Радојчић В. Дејан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 2
final exam: written
parent department: naval systems

goals

The aims of the course are to make the student familiar with:
1) Essential features of ship maneuverability so that the navigation is as safe as possible;
2) Standard tests and criteria for ship maneuverability estimation;
3) ITTC and IMO regulations;
4) Ship design in respect to its maneuverability (course keeping, turn ability, response to rudder deflection etc.).

learning outcomes

The student should know:
1) Basic features of ship maneuverability and criteria for its estimation;
2) To interpret regulations for maneuverability and to conduct maneuverability tests; 3) To know which measures should be undertaken in ship design to provide satisfactory ship maneuverability.

theoretical teaching

Theoretical teaching focuses on familiarizing the student with:
- General principles of maneuverability,
- Necessary mathematical formulations and stability criteria.
- Introduction of standard maneuverability tests (spiral and reverse spiral test, zig-zag maneuver, turning path, pullout test etc.). Captive and free running model tests (PMM, rotating arm technique etc.) are explained. Hydrodynamics of control surfaces (rudders) follows.

practical teaching

Practical teaching focuses on the application of knowledge to common engineering practice. Practical explanations are given for performing standard maneuverability tests. Students are familiarized with active (bow thrusters etc.) and passive control devices (various types of rudders). Recommendations are given for ship design and meeting the criteria defined by IMO regulations.

prerequisite

There are no prerequisites.

learning resources

1. Extracts from lectures (handouts)
2. Reports from the measurements
3. Control devices - manufacturers' brochures
4. The Internet resources.

number of hours

total number of hours: 30

active teaching (theoretical)

lectures: 12

active teaching (practical)

auditory exercises: 10
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 2
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 1
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 45
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 50
requirements to take the exam (number of points): 25

references

E. Lewis, (editor): Principles of Naval Architecture (Chapter IX – Controllability), SNAME, Jersey City, 1988.
J. Brix: Maneuvering Technical Manual, Seehafen Verlag, Hamburg, 1993.
A.F. Molland, S.R. Turnock: Marine Rudders and Control Surfaces, Butterworth – Heinemann, 2007

Ship Propulsion

ID: MSc-0178
teaching professor: Радојчић В. Дејан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: naval systems

goals

The aims of the course are to familiarize the student with various types of ship propulsors (specifics, advantages and drawbacks, selection of the best propulsor etc.).
Practical training should enable the student to select/design the most adequate propulsor by applying common engineering methods, to use computer for those activities, to know how to determine necessary engine power.

learning outcomes

The student should be familiar with various types of ship propulsors and propellers in particular, their advantages and drawbacks, the concept of ship propeller design by applying common engineering methods, how to determine the needed ship engine power output.

theoretical teaching

Theoretical teaching involves familiarity with interaction between the hull and the propeller (propulsive coefficients), joint operation of the ship propeller and the engine, types of propellers and, lastly, the selection/design of propellers by using common engineering methods. Explanations are given of basic elements needed for the sea trials. The model tests and interpretation of their results are examined too. Finally, the student is familiarized with various types of propulsors based, more or less, on the screw propeller (for example, propeller in the nozzle) as well as with those that are considerably different and are often installed in unconventional ship types or boats (for example, water-jet propulsor). Also, transmission of power from the engine to the propulsor, which influences propulsor in great extent, is mentioned.

practical teaching

In addition to common calculation examples that follow teaching units presented theoretically, the focus is on the student's independent design of project (which is actually a continuation of the project included in the Ship resistance course). The project, in brief, consists of performing calculations by applying common engineering methods (some with the use of the computer) to select/design the optimal propeller and then choose an adequate ship engine. Besides, the student should produce a technical drawing of the propeller.

prerequisite

Exam passed in SHIP RESISTANCE is a must.

learning resources

1. Extracts from lectures (handouts).
2. Instructions for project design.
3. The Internet resources.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 10
laboratory exercises: 0
calculation tasks: 10
seminar works: 0
project design: 10
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 10
colloquium, with assessment: 0
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 30
final exam: 60
requirements to take the exam (number of points): 20

references

E. Lewis,(editor): Principles of Naval Architecture (Chapter VI – Propulsion), SNAME, Jersey City, 1988.
Sv. AA. Harvald: Resistance and Propulsion of Ships, John Willey & Sons, 1983.
T. P. O’Brien: Design of Marine Screw Propellers, Hutchinson & Co. Ltd., London, 1969.
A. J. W. Lap, J. D. Van Mannen: Fundamentals of Ship Resistance and Propulsion (Part B – Propulsion), NSMB Publication 129A.

SHIP RESISTANCE

ID: MSc-0273
teaching professor: Радојчић В. Дејан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: naval systems

goals

The aims of the course are to familiarize students with:
1) fundamentals of ship hydrodynamics; how elementary ship form parameters affect ship resistance;
2) how to determine resistance for conventional ships types by applying standard engineering methods and by analyzing the results of model tests;
3) unconventional types/forms of ships from the aspect of ship resistance (shallow draught river vessels, planing and semi-displacement high speed craft, etc.).

learning outcomes

1) Basic knowledge about ship hydrodynamics needed for the design of conventional types of ships.
2) Ability to do calculations of ship resistance at the common engineering practice level.
3) Knowledge about basics of model tests and extrapolation of results from model to ship scale.
4) Basic knowledge about unconventional ship types and their forms.

theoretical teaching

To determine the ship's main engine power, ship resistance must be determined first. It can be obtained by model tests or by other evaluation methods. Teaching is primarily oriented to practical application of ship hydrodynamics in common engineering practice. Attention is particularly focused on model tests that are still the most reliable tool as well as on the extrapolation of results from a model to a ship. Theoretical teaching is realized through the following teaching units: a) calculations of ship resistance components, resistance evaluation according to ITTC recommendations/method, b) effects of shallow and restricted water, c) model tests, model-ship correlation, standard methodical and statistical series, d) recommendations for design of ship forms, and e) high-speed (unconventional) craft.

practical teaching

The student should evaluate resistance for a usual sea-going ship (form) he/she was acquainted within the subject Buoyancy and stability of ship 1; obtained results will be used in the project that should be done within Ship propulsion course. Thus, the student is enabled to perceive the ship as a whole, and resistance itself as a part of applied ship hydrodynamics that is unavoidable in the ship design process. Within the framework of practical teaching the student is trained to do calculations using a computer i.e. to develop a mathematical model for resistance evaluation by himself. Moreover, some teaching units presented by theoretical teaching involve calculation examples too.

prerequisite

Exams passed in Fluid mechanics (Hydromechanics)and Buoyancy and stability of ship 1

learning resources

1. Extracts from lectures (handouts)
2. Instructions for project design
3. The Internet resources.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 8
laboratory exercises: 0
calculation tasks: 9
seminar works: 0
project design: 8
consultations: 5
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 10
colloquium, with assessment: 0
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 30
final exam: 60
requirements to take the exam (number of points): 20

references

E. Lewis (editor): Principles of Naval Architecture (Chapter V – Resistance), SNAME, Jersey City, 1988.
Sv. AA. Harvald: Resistance and Propulsion of Ships, John Willey & Sons, 1983.
M. Hofman, D. Radojcic: Resistance and Propulsion of High Speed Vessels in Shallow Water (in Serbian), Masinski fakultet, Beograd, 1997.
A. J. W. Lap, J. D. Van Mannen: Fundamentals of Ship Resistance and Propulsion (Part A – Resistance), NSMB Publication 129A.

Ship Strength 1

ID: MSc-0288
teaching professor: Моток Д. Милорад
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: naval systems

goals

The aims are to explain: basic modes of ship structure failure and limit state assessment of ship structure, general simplification of the hull mathematical model and the concept of strength calculations by using analytical and numerical methods.

learning outcomes

A thorough knowledge about the concept of ship strength calculations in contemporary shipbuilding practice. Qualification for practical application of analytical methods of theory of elasticity in direct calculations of ship structures and analysis and development of classification societies' rules.

theoretical teaching

The student is familiarized with various types of ship structure failure and limit states. Basic hull
loadings are considered and their classification into static, quasi-static and dynamic ones is explained. Basic concept of the analysis of primary, secondary and tertiary structure response is
explained as well as conditional division of those calculations into longitudinal, transverse and local strength. Studies comprise, first of all, analytical and some numerical methods for calculations of beams, grids, unstiffened and stiffened plates of ship structure. Explanations are given of a general concept of the corresponding hull mathematical model, simplifications to be applied for the sake of analytical methods use, limitations of such approach to analysis, and alternative numerical methods that help to overcome those limitations.

practical teaching

Calculation tasks are used to develop student ability to independently do strength calculations of beams and plane grids of ship structure, and analysis of bending and stability of unstiffened plates and stiffened panels of ship structure. In modern engineering practice those skills are needed in both direct calculations of the hull strength and for understanding and development prescriptive formulas in classification societies' rules.

prerequisite

Defined by the Study Program Curriculum

learning resources

1. Examples of solved calculation tasks /In Serbian/
2. Shipbuilding rules by various classification societies /In Serbian and English/

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 17
laboratory exercises: 0
calculation tasks: 10
seminar works: 0
project design: 0
consultations: 3
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 5
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 5
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 50
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 40
requirements to take the exam (number of points): 10

references

M. Motok: Ship Strength /In Serbian/, MF, Beograd, 2005.
J. Khlitchiev: Chapters on Calculations of Ship Structures /In Serbian/, MF, Beograd, 1972.
J. Ursic: Ship Strength I, II, III /In Serbian/, FSB, Zagreb, 1972.1991.1992
O. F. Hughes: Ship Structural Design, John Wiley & Sons, New York,1983.
***: Ship Design and Construction, Vol I, SNAME, 2003.

Ship Strength 2

ID: MSc-0312
teaching professor: Моток Д. Милорад
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: naval systems

goals

The aims of the course are to explain the basic principles of numerical methods for structural analysis, theoretical and practical fundamentals of finite element method and to provide a thorough explanation of finite element method application in ship structure design.

learning outcomes

A thorough knowledge about the concept of structural analysis by applying finite element method as one of the most significant methods for structural analysis in contemporary engineering practice. Qualification for practical application of a commercial FEM program package in direct computations of ship structure.

theoretical teaching

Teaching focuses on the finite element method as one of the most significant numerical methods for structural analysis in contemporary engineering practice. The idea is to organize the
course as a first encounter with finite element method for those students for whom it is not a major subject of study but only one of the tools they have to master to manipulate. That is why a portion of approach is simplified, where it is not insisted upon all details of mathematical derivations but upon aspects essential to proper practical FEM analysis by applying commercial program packages.

practical teaching

The student is trained to independently do computations for typical models of ship structure by using a computer and commercial program packages. It is started from less complex beam models – ship's cross-sectional frames and plane hull structure grids, and through models of stiffened and unstiffened panels, involving thin plate finite elements, it is gradually arrived at complex web frame and three hold models.

prerequisite

Exam passed in Ship Strength 1.

learning resources

1. Commercial FEM computer programs
2. Instruction manual for commercial FEM programs use /In English/

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 10
laboratory exercises: 18
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 2
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 5
test, with assessment: 5
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 50
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 40
requirements to take the exam (number of points): 40

references

M. Motok: Ship Strength /In Serbian/
M. Kalajdzic: Finite Element Method /In Serbian/, IAMA, Beograd, 1978.
C.T.F Ross: Advanced Applied Finite Element Methods, Harwood Publishing, Chichester,1998.
O.F. Hughes: Ship Structural Design, John Wiley & Sons, New York,1983.
***: Ship Design and Construction, Vol I, SNAME, 2003.

Ship Structures 2

ID: MSc-0197
teaching professor: Моток Д. Милорад
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: naval systems

goals

A thorough explanation of the hull girder longitudinal strength calculation. An explanation of specific requirements that have to be met by the hull of the three most prominent ship types: a container ship, a bulk carrier and a tanker.

learning outcomes

The student should be able to practically perform hull girder longitudinal strength calculation according to classification societies' rules. A thorough knowledge should be acquired of specifics, general conception and the hull structural members of tankers, bulkers and container ships.

theoretical teaching

The first part of the course considers basic principles and methodology of longitudinal strength calculation: determination of hull girder loading on the basis of specific buoyancy and specific weight per ship unit length; determination of geometrical characteristics of hull girder crosssection;
computations of wave induced transverse force and bending moment using
classification societies' empirical formulas; analysis of the overall stress state. The second part of
the course comprises basic structural members and specifics of the hull structure in a tanker, a bulk carrier and a container ship – their names, appearance, basic functions, conditions and loadings they undergo during exploitation, methods of construction.

practical teaching

A detailed prominent example is used to explain the procedure for hull girder longitudinal strength calculation according to classification societies' rules. Within the framework of independent design project of "his own ship" the student determines: equivalent hull girder loading on the basis of specific buoyancy curve and specific weight curve per ship unit length; geometrical characteristics of hull girder cross-section; wave induced transverse force and bending moment using classification societies empirical formulas and conducts final analysis of the overall stress state.

prerequisite

Exam passed in Ship Structures 1.

learning resources

[1] Lectures are available in electronic form /In Serbian/
[2] A detailed prominent example of the project
[3] Various classification societies' rules

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 9
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 17
consultations: 4
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 7
colloquium, with assessment: 0
test, with assessment: 3
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 15
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 30
final exam: 50
requirements to take the exam (number of points): 35

references

M. Grubisic: Ship strucrures /In Serbian/, FSB, Zagreb, 1980.
***: Ship Design and Construction, SNAME, 2003.
D.J. Eyres: Ship Construction, London,1972.
N. Barabanov: Structural Design of Seagoing Ships, Peace Publishers, Moscow, 1980.

SKILL PRAXIS M – БРО

ID: MSc-0089
teaching professor: Моток Д. Милорад
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 1
final exam: seminar works
parent department: naval systems

goals

The student gains practical experience in the occupational environment where he will pursue his future
career. He identifies essential functions of the business system in the domain of design, development
and manufacturing as well as the role and tasks of a naval architect within such business system.

learning outcomes

The student should gain practical experience in the way of organizing and functioning of the environment where he will apply the acquired expert knowledge, identify models of communication
with his colleagues and business information flows, identify fundamental processes in design, manufacturing, maintenance within the context of his future competence, establish personal contacts
and acquaintances he will make use of during his schooling, or when applying for job in the future.

theoretical teaching

practical teaching

Practical teaching involves work in organizations where various activities are performed that have to do
with naval architecture. The student chooses thematic unit and manufacturing company or research
institution after consulting the Professor. In general, the student is allowed to conduct skill praxis in:
shipyards, design and consulting agencies, companies dealing with ship and machinery maintenance, or
one of the laboratories at the Faculty of Mechanical Engineering. Skill praxis can be done abroad as well.
The student is obliged to keep a diary of skill praxis, where he will describe jobs he is doing, record his
conclusions and remarks. After he completes the skill praxis, the student makes a report and provides
explanations to the Professor. The report is handed over in the form of a seminar work.

prerequisite

learning resources

number of hours

total number of hours: 46

active teaching (theoretical)

lectures: 0

active teaching (practical)

auditory exercises: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 0
final exam: 46

assessment of knowledge (maximum number of points - 100)

feedback during course study: 70
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

Software Application in Ship Design

ID: MSc-0144
teaching professor: Хофман М. Милан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 4
final exam: oral
parent department: naval systems

goals

The goal of course is acquiring knowledge in the field of shipbuilding graphics, computer programs for developing ship form, hydrostatic computations, power prediction, hull structure scantling, seakeeping and ship design.

learning outcomes

Practical knowledge in applying computer programs for developing ship form, hydrostatic computations, power prediction, hull structure scantling, seakeeping and ship design.

theoretical teaching

Concepts and basic aspects of the application of computer programs and commercial software packages for naval architecture. Some basic software packages connected to ship geometry, lines drawing, hydrostatic computations, hull construction, power prediction, ship manoeuvring and seakeeping are explained and demonstrated.

practical teaching

Students are trained to work with available software packages, in order to solve practical engineering problems of ship geometry, lines drawing, hydrostatic computations, construction, power prediction, manoeuvring and seakeeping. The course is parallel to the Ship Design, and the students use the software for developing their individual ship design project.

prerequisite

Exams passed in Buoyancy and Stability of Ship 2, Ship Resistance, Ship Propulsion, Ship Structures 2.

learning resources

[1] Extracts from lectures (handouts).
[2] Support for software packages: AutoCAD, DelftSHIP, AutoShip (ModelMaker, AutoHydro), HydroComp, GL Rules.
[3] Internet resources.

number of hours

total number of hours: 45

active teaching (theoretical)

lectures: 18

active teaching (practical)

auditory exercises: 0
laboratory exercises: 18
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 4
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 0
laboratory exercises: 60
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

DELFTshipTM user manual
AutoCAD user manual

Software Application in Ship Design

ID: MSc-0533
teaching professor: Бачкалов А. Игор
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 4
final exam: written
parent department: naval systems

goals

To cover the application of computer program packages for ship design and basic ship calculations.

learning outcomes

Practical knowledge in applying computer programs for developing ship form, hydrostatic computations, power prediction, hull structure scantling, seakeeping and ship design.

theoretical teaching

Concepts and basic aspects of the application of computer programs and commercial software packages for naval architecture. Some basic software packages connected to ship geometry, lines drawing, hydrostatic computations, hull construction, power prediction, ship manoeuvring and seakeeping are explained and demonstrated.

practical teaching

Students are trained to work with available software packages, in order to solve practical engineering problems of ship geometry, lines drawing, hydrostatic computations, construction, power prediction, manoeuvring and seakeeping. The course is parallel to the Ship Design, and the students use the software for developing their individual ship design project.

prerequisite

Exams passed in Buoyancy and Stability of Ship 2, Ship Resistance, Ship Propulsion, Ship Structures 2.

learning resources

[1] Extracts from lectures (handouts).
[2] Support for software packages: AutoCAD, DelftSHIP, AutoShip (ModelMaker, AutoHydro), HydroComp, GL Rules.
[3] Internet resources.

number of hours

total number of hours: 45

active teaching (theoretical)

lectures: 18

active teaching (practical)

auditory exercises: 0

laboratory exercises: 18
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 4
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 0
laboratory exercises: 60
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

DELFTshipTM user manual
AutoCAD user manual

physics and electrical engineering

Biomedical instrumentation and equipment
Electric Machinery
Electronics
Quantum information technologies

Biomedical instrumentation and equipment

ID: MSc-0287
teaching professor: Лукић М. Петар
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: physics and electrical engineering

goals

Introducing to standard measuring and diagnostically medical methods and implementation of electron devices in medicine. The focus is on the principles and operation methods of the biomedical equipment with brief description of device construction. The subject educates engineers to improve still existing and develop new biomedical equipment.

learning outcomes

By attending the course, students will be educated to understand and analyze problems concerned with operation and usage of biomedical instrumentation and equipment. This course educate students to connect basic principals of electronics, physics and medicine and to practically implement them into modern medical equipment.

theoretical teaching

Principles of medical measurements and instrumentation. Sensors for biomedical measurements. Electric and magnetic stimulators. Ultrasound in medicine - overview of the diagnostically methods: tomography, cardiosonography, measurement of blood flow (Doppler). Methods based on medical imaging - Rontgen, computer tomography, Anger camera, nuclear magnet resonasy, positron emitting tomography, thermograph. Medical image processing. Medical image generation: digital and digitalized image. Basic methods for image processing.

practical teaching

Principles of medical measurements and instrumentation. Overview of the sensors and their characteristics that are used for biomedical measurements. Basic modules of the electric muscle stimulator - presentation. Ultrasound in medicine - overview of the diagnostically methods: tomography, cardiosonography, measurement of blood flow (Doppler). Generating of the medical image - examples. Digitalization of analogous image. Medical image processing. Basic methods for image processing. Basic methods for digital medical image improving. Morphology methods for image processing. Practical examples.

prerequisite

Electrical engineering and Electronics
Electronics and biomedical measurements

learning resources

[1] Joseph D. Bronzino (editor): The Biomedical Engineering - Handbook, CRC Press, IEEE Press, USA, 1995. КСЈ
[2] D. M. Škatarić, N. V. Ratković, T. M. Stojić, P. M. Lukić: Solved Numerical Problems in

Electro technique, Faculty of Mechanical Engineering, Belgrade, 2000.
[3] D. B. Kandić: Electro technique, Faculty of Mechanical Engineering, Belgrade,2002.
[4] Handouts

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 25
laboratory exercises: 0
calculation tasks: 0
seminar works: 3
project design: 0
consultations: 2
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 3
check and assessment of projects: 0
colloquium, with assessment: 3
test, with assessment: 4
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 15
test/colloquium: 35
laboratory exercises: 0
calculation tasks: 0
seminar works: 15
project design: 0
final exam: 35
requirements to take the exam (number of points): 35

references

Joseph D. Bronzino (editor): The Biomedical Engineering - Handbook, CRC Press, IEEE Press, USA, 1995.
Dejan Popović, Mirjana Popović: Biomedical instrumentation and equpment, Nauka, Belgrade, 1997.

Electric Machinery

ID: MSc-0401
teaching professor: Шкатарић М. Добрила
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: physics and electrical engineering

goals

Understanding and accepting basic laws in electric machinery field; according to this knowledge students will be able to describe and recognize some important problems in many engineering fields: Mechanical engineering, bio-medicine, food processing industry, and power engineering. The students will meet during the course different types of electric machines.

learning outcomes

After this course students will be able to menage some problems from engineering practise as well as the problems in other fields where these machines are applied.Also, they will be capable in solving some research problems due to the presented methods and measuring techniques.Understanding new methods and techniques, and new equipment.

theoretical teaching

Magnetic circuits: Intro,basic components, permeability and hysteresis.
Transformers: power transformers, autotransformers, measuring transformers; basic equations, measurements, connections.
Electro- mechanical systems; energy conversion principles; force and torque equations.
Dc Machines: motors and generators; basic equations, moment characteristics, efficiency.
Induction motors (3 phase): principles and equations; construction; implementation.
Synchronous machines: types, construction, equations, principle of operation, implementation.
Single phase induction motors : specifics in construction and operation
Step motors: construction and principles of work; implementation.
Control of electric machinery: classical and modern control principles(electronic, frequency, etc)

practical teaching

Practical training:1)recitation(numerical problems in all fields)2) laboratory experiments. Recitations are according to lecturing in transformers, induction motors, generators and many other combination from the engineering practice. Homework problems are included too. Laboratory experiments: Power measurement in 3 phase systems; demonstration of different machines operation, such as synchronous generator, DC machines as well as measuring some basic characteristics of these machines.Frequency regulation.

prerequisite

no specific conditions

learning resources

1. Hand-outs
2. Del Toro V., Electrical Engineering Findamentals, Prentice-Hall, New Jersey, 1986, KDA;
3. Nasar S., Electric Machines and Electromechanics, Schaum's Outline Series, McGraw-Hill,

1998, KDA;

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 20
laboratory exercises: 4
calculation tasks: 4
seminar works: 0
project design: 0
consultations: 2
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 2
check and assessment of lab reports: 2
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 6
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 40
laboratory exercises: 15
calculation tasks: 10
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

Electronics

ID: MSc-0224
teaching professor: Кандић Б. Драган
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: physics and electrical engineering

goals

The aim of the course is to familiarize the students with basic laws of electronics engineering and to develop student competence for acquisition of more advanced academic knowledge and practical skills in scientific, professional and applied areas of mechanical engineering relying on electronics. The student is introduced into basic devices, circuits and systems encountered in electronics engineering and scientific methods for their analysis and practical measurements.

learning outcomes

Having successfully mastered the teaching contents of Electronics, the student should be able to qualitatively pursue his scientific career and profession, manipulate methods of analysis and measurements in electronics, anticipate the solutions and perceive the outcomes, acquire an understanding of research and practical methods in the fields he can adequately apply in concrete problem-solving in mechanical engineering.

theoretical teaching

-Definition of electronics and a brief historical overview. Electronic signals and systems
-Elements of semiconductor physics (semiconductor crystal structure, intrinsic and extrinsic semiconductors, basic transport phenomena)
-PN-junction (physical structure, open-circuited and operation with applied direct and inverse polarization, capacitance of depletion layer, diffusion capacitance, voltage breakdown)
-Semiconductor diodes (current-voltage characteristic, models for small and large signals, temperature characteristics, distribution of currents and voltages in diode circuits, switching operation, special purpose diodes-Zener, Schottky, tunnel and PIN, selected applications)
-Bipolar junction transistors (principle of operation, distribution of currents, amplifying property, large-signal model, current-voltage characterics, biasing, small-signal operation and models, high-frequency operation, basic BJT amplifier configurations, breakdown and temperature effects, switching operation)
-Field-effect transistors-JFET and MOSFET (principle of operation, current-voltage characterics, biasing, small-signal operation and models, switching operation)
-Amplifiers (transfer-function, equivalent circuit, feedback, frequency-response). Operational amplifiers (properties, common circuits and selected applications in linear and nonlinear signal processing)
-Oscillators (sinusoidal and relaxation, analysis, types, amplitude an frequency stabilization)
-Power amplifiers (with BJT, transformer-coupling and complementary pair)
-Components of power electronics (thyristor, diac and triac, application in power-regulation circuits)
-Elements of digital electronics (number systems, Boolean algebra, switching functions, basic logic gates, combinatorial and sequential circuits)
-A/D and D/A converters.

practical teaching

Auditorial exercises involve presentation of numerical examples and problems, all complying with theoretical teaching.

Four laboratory exercises are scheduled:

1) Common diode applications (rectifiers, limiters and clampers)
2) One-stage BJT common-emitter voltage amplifier (operating-point adjustment and recording of amplitude-frequency response)
3) Selected Op-Amp circuits in linear and nonlinear signal processing
4) Logic gates. Selected combinatorial circuits. Counters.

The intense application of LT Spice IV, LogiSim and student version of Multisim is conceived in both types of exercises.

prerequisite

Defined by the Study Program Curriculum

learning resources

1. S. Tešić, D. Vasiljević: Electronics fundamentals, Građevinska knjiga, Beograd, 2009 /In Serbian/, ISBN 978-86-395-0572-1.
2. M. Živanov: Electronics fundamentals-components, FTN, Novi Sad, 2004 /In Serbian/, ISBN 86-85211-16-6
3. M. Živanov: Electronics fundamantals-amplifier circuits, FTN, Novi Sad, 2004, /In Serbian/, ISBN 86-85211-02-6
4. V. Drndarević: Electronics, SF, Belgrade, 2005 /In Serbian/, ISBN 86-7395-181-X
5. B. Aničin: Electronics fundamentals, MF, Beograd, 1995 /In Serbian/
6. M. Živanov: Electronics fundamentals-Exercises, FTN, Novi Sad, 2004 /In Serbian/, ISBN 86-85211-17-4
7. Printed extracts from lectures ("handouts")/In Serbian/
8. Licensed software, LT Spice IV, LogiSim and other student-version software.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 24
laboratory exercises: 4
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 2
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0

check and assessment of lab reports: 4
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 8
final exam: 3

assessment of knowledge (maximum number of points - 100)

feedback during course study: 4
test/colloquium: 50
laboratory exercises: 16
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

1. A. Sedra, K. C. Smith: Microelectronic circuits, 6th Edition, Oxford University Press, NY, 2011, ISBN 978-019-973851-9.
2. R. Boylestad, L. Nashelsky: Electronic devices and circuit theory, 10th Edition, Prentice Hall, NY, 2009, ISBN 978-0-13-606463-3.
3. T. L. Floyd: Electronic devices, 8th Edition, Prentice Hall, NY, 2008, ISBN 978-0-13-615581-2.
4. R. Tokheim: Digital electronics principles and applications, 7th Edition, McGraw-Hill, NY, 2008, ISBN 978-0-07-312634-0.
5. J. J. Cathey: Theory and Problems of Electronic Devices and Circuits, McGraw-Hill, NY, 2002, ISBN 0-07-136270-3.

Quantum information technologies

ID: MSc-0330
teaching professor: Илић Т. Јелена
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: physics and electrical engineering

goals

Introduction of principles of quantum information technologies in order to apply them in medical diagnostics and informatics (genomic analysis), in connection of the central nerve system with artificial parts of the body (arm, leg, ear, eye ...) and organs of quadriplegic, paraplegic and hemiplegic patients. Learning the basics of terminology and logic of quantum information technologies that are essentially different from those in classic information technologies.

learning outcomes

Capability and readiness of students to accept and apply new quantum information devices in medical informatics. Understanding of functioning principles and specific conditions of applications of quantum information devices. The application and development of nuclear magnetic resonance technique in quantum information technique.

theoretical teaching

The history of quantum communications and quantum information techniques. Qubit – a unit of quantum information. Types of qubits according to its physical nature. Initialization, manipulation and detection of a qubit. The principles of quantum-communication internet protocols. Quantum measurements: Heisenberg limit, quantum atomic clock. Quantum optics: control of the states and photon detection, one-photon detectors and sources, quantum tomography. History and basics of quantum cryptography. Quantum logical circuits. The problem of decoherence of components of quantum computers, and its solution by shaping of optical pulses. Quantum noise. Peculiarities of quantum programming. Quantum computers based on ion-traps, nuclear magnetic resonance, semiconductors, superconductivity and fullerenes.

practical teaching

Exercises of recognition of types and states of a qubits. Examples of qubit manipulations. Examples of quantum communication internet protocols. Calculation of limits of quantum measurements. Examples of quantum tomography. Solving the problems of quantum logical circuits. Examples of quantum programming and quantum programming languages. Examples of solving the problems of decoherence and quantum noise. Examples of biomedical application of quantum computers based on ion-trap. Application of quantum computers based on nuclear magnetic resonance in liquid or solid state materials. Examples of biomedical applications of quantum computers based on semiconductors, and superconductivity.

prerequisite

necessary: Physics and measurement, Programming, Electrotechnics, Quantum mechanics.
desirable: Computational tools, Basics of biomedical engineering.

learning resources

[1] Written lectures (handouts), [2] Dugić Miroljub, Basics of quantum informatics and quantum computing, PMF, Kragujevac, 2009, [3] M.Srećković, S.Ostojić, S.Ristić, J.Ilić, V.Arsoski, Collection of problems in quantum electronics, Technical faculty, Čačak, 2007.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 18
laboratory exercises: 0
calculation tasks: 4
seminar works: 3
project design: 0
consultations: 0
discussion and workshop: 5
research: 0

knowledge checks

check and assessment of calculation tasks: 2
check and assessment of lab reports: 0
check and assessment of seminar works: 5
check and assessment of projects: 0
colloquium, with assessment: 4
test, with assessment: 1
final exam: 3

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 40
laboratory exercises: 0
calculation tasks: 5
seminar works: 15
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

Raković Dejan, Integrative Biophysics, Quantum Medicine, and Quantum Holografic Informatics: Psychosomatic – Cognitive Implications, IASC and IEFPG, Belgrade, 2008.
Nielsen Michael, Chuang Isaak, Quantum Computation and Quantum Information, Cambridge University Press, Cambridge, 2000.

process and environmental protection engineering

Air Pollution Control
Biotechnology
Burning, technical and medical gases
Chemical and Biochemical Operations and Reactors
Combustible, technical and medical gases
Concepts of environmental and workplace protection
Design, construction and operation of processing systems
Draying and drayers
Efficiency of process end energy systems
Equipment of process systems
Heat transfer operations and equipment
Industrial furnaces and boilers
Mass transfer operations and equipment
Measurements and Control in Process Industry
Mechanical and hydromechanical Operations and Equipment
Process Energetics
Skill practice M - PTH
Technical regulations
Waste and wastewater management
Transport phenomena in process industry

Air Pollution Control

ID: MSc-0124
teaching professor: Радић Б. Дејан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 2
final exam: written+oral
parent department: process and environmental protection engineering

goals

The goal of course is a review of basic design devices used in facilities whose purpose is the air pollution control. This is achieved through a review of the basic construction of apparatus for the purification of gases and review of methofdology for calculations commonly used types of these devices. In this way the student masters the skills of designing these facilities and individual devices.

learning outcomes

Upon completion of the course is expected that the candidate has mastered the skills related to analysis and evaluation of application of air pollution control devices for a particular purpose. The knowledge that the student acquire the specific technical solutions, selection of treatment methods and equipment enabling the understanding of basic principles essential for the design of air pollution control installations and calculation of particular devices.

theoretical teaching

Apparatus for particulate emission reduction – Inertial and gravitational devices, centrifugal separators, electrostatic precipitators, fabric filters.
Apparatus for wet particulate and gas emission reduction – Spray towers, scrubbers (spray, cyclone, baffle, impigment etc), venturi scrubber.
Dry, wet and semidry gas emission control – wet scrubbers, absorbers, adsorbers, packed bed absorbers, condensers.
SOx, NOx and VOC control.

practical teaching

Design of settling chambers.
Design of centrifugal separators.
Design of fabric filters.
Design of wet scrubbers.
Desing of Venturi scrubbers.
Material balances of air pollution control devices.
Design od apsorbers for gas cleaning.
NOx removal devices.
VOC removal devices.
Laboratory – measurement of particulate and gas emission.

prerequisite

Defined by curriculum of study program/module.

learning resources

1. Kuburović, M., Jovović A., Stanojević, M., Karan, M., Radić, D., Petrov, A.: Environmental

protection (Chapter 15), Termotehničar, Interklima – V. Banja, SMEITS–Belgrade, 2004., KPN
2. Vuković, D, Bogner, M.: Cleaning technique, SMEITS, Belgrade, 1996, KDA
3. Experimental installation for air emission measurements, Laboratory for process engineering (room 6) EOP-LPI
4. Devices and apparatus for for air emission measurements, Laboratory for process engineering (room 6) EOP-LPI

number of hours

total number of hours: 30

active teaching (theoretical)

lectures: 12

active teaching (practical)

auditory exercises: 11
laboratory exercises: 1
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 1
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 15
test/colloquium: 0
laboratory exercises: 15
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 70
requirements to take the exam (number of points): 20

references

S.Calvert, H.M.Englund, Handbook of Air POLUUTION Technology, John Wiley & Sons, 1984.
C.C.Lee, S. D. Lin, Handbook of Environmental Engineering Calculations, Second Editions, Mc Graw Hill, 2007.

Biotechnology

ID: MSc-0323
teaching professor: Станојевић М. Мирослав
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: process and environmental protection engineering

goals

The purpose of subject is for students to get knowledge about basic processes and equipment, which is used in biotechnology. Through the semester students' projects, students get creative and specific practical skills for construction of process equipment. The laboratory exercises have the aim to give appropriate knowledge to students about examination of process equipment during the production as well as the exploitation process.

learning outcomes

After successful course attending students get ability for: analysis, synthesis and predicting solutions and consequences; developing of critic and self critic thinking and approach; practical knowledge implementation; professional ethic; connecting knowledge from different subjects and their implementation; developing skills and abilities for knowledge implementation in adequate area.

theoretical teaching

1. Basics of biotechnology (definitions, products and raw materials), 2. Basics processes and designing of biotechnology, 3. Bioreactors (continuous, batch), 4. Processes and equipment of biotechnology, 5. Processes, equipment and materials for sterilization processes (thermal and mechanical processes), 6. Mathematical modeling of fermentation processes (Monod equation, stoichiometry of bioprocess), 7. Biotechnological processes for waste materials treatment (waste water: bioaeration tanks, biofilters, biodiscs; solid waste: composting, landfills), 8. Treatment of waste materials in anaerobic processes (digesters, landfills), 9. Biotechnological processes for gas cleaning.

practical teaching

1. Basic products of biotechnology, 2. Raw materials in biotechnological processes, 3. Selection of bioreactors construction, 4. Construction characteristics of bioreactors, 5. Laboratory exercise: Determination of aerator characteristics in bioreactors with aeration agitation, 6. Determination of thermal sterilization process parameters, 7. Equipment for sterilization processes, 8. Biological treatment methods of domestic, industrial and agricultural waste, 9. Biotechnological equipment for waste water treatment, 10. Design of bioreactors – anaerobic digesters.

prerequisite

Elective course. There is no specific requirement for course attending.

learning resources

1. Kuburović, M., Stanojević, M.: Biotechnology – processes and equipment, Edition "Process technique", SMEITS, Belgrade, 1997., KPN
2. Laboratory facility for determination of aerator characteristics in bubble aeration

bioreactors, Laboratory of process technique (room 6), LPI

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 19
laboratory exercises: 2
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 9
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 4
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 6
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 45
laboratory exercises: 20
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

Kuburović, M., Stanojević, M.: Biotechnology – processes and equipment, Edition "Process technique", SMEITS, Belgrade, 1997., KPN
Bogner, M. at all.: Handbook of thermal technique, Interklima grafika, Vrnjačka Banja, 2003
Rehm, H. J., Reed, G., Brauer, H.: Biotechnology, Vol. 2, Fundamentals of Biochemical Engineering, VCH Verlagsgesellschaft, mbH, Weingeim, 1985.
Jackson, A. T.: Proces Engineering in Biotechnology, Open University Press, Buckingham, 1990.
Veljković, V.: Basics of biochemical engineering, Faculty of technology, Leskovac, 1994.

Burning, technical and medical gases

ID: MSc-0151
teaching professor: Петровић Љ. Александар
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 2
final exam: written
parent department: process and environmental protection engineering

goals

learning outcomes

theoretical teaching

practical teaching

prerequisite

learning resources

number of hours

total number of hours: 30

active teaching (theoretical)

lectures: 12

active teaching (practical)

auditory exercises: 12
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 1
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 40
laboratory exercises: 0
calculation tasks: 0

seminar works: 0
project design: 0
final exam: 50
requirements to take the exam (number of points): 30

references

Chemical and Biochemical Operations and Reactors

ID: MSc-0301
teaching professor: Радић Б. Дејан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: process and environmental protection engineering

goals

The purpose of subject is for students to get knowledge about theories of kinetic and dynamic of physical-chemical transformations in various technological processes. Influence of process parameters to gaining conditions for physical and chemical equilibrium is separately considered. Getting knowledge about basic models of chemical reactors, types of chemical reactions, rules used for qualitative and quantitative description of complex physical-chemical phenomenon and mass and heat balance equation, gives students basic for independent projecting of technologies and systems of process industry.

learning outcomes

Successful completion of the study program the student acquires the knowledge necessary to understand the kinetics of chemical reactions and to master the methodology of calculation of chemical processes and reactors. Introduction to basic models of chemical reactors and material equations and thermal balance should allow students to independently analyze the real process, that the application of engineering and scientific methods to be able to design processes and systems.

theoretical teaching

Classification of chemical reactions. Mechanism of complex chemical reactions. Chemical equilibrium. Chemical equilibrium constant. Influence of process parameters on chemical equilibrium and chemical reaction. Material and heat balance of chemical reactions. Heats and free energies of formation. Enthalpy, entropy and free energy. Half life. Degree of conversion. Kinetic equation of chemical reaction. Rate of chemical reaction. Order of chemical reaction. Basic principles of design of heterogeneous systems. Rate constants of complex reactions. Classification and models of chemical reactors. Ideal chemical reactors. Material and heat balance of reactor. Batch reactors. Continuous stirred-tank reactors. Plug flow reactors. Cascade of continuous ideal reactors. Analysis of rate equations. Analysis and modeling of chemical reactors. Design of chemical reactors and processes.

practical teaching

Calculations of multicomponent and multiphase systems. Determination of chemical equilibrium constant.
Basic principles of thermodynamic for chemical reactions. Heat effect of chemical reactions. Exothermic and endothermic chemical reactions.
Analysis of complex chemical reactions.
Calculation of the rate of chemical reaction. Order of chemical reactions.
Design of chemical reactors and processes – material and heat balances.
Calculations of ideal reactors (batch reactors, continuous stirred-tank reactors, plug flow reactors, cascade of continuous ideal reactors).
Comparation and selection of type of reactor.
Chemical reactor plant. Process optimization.

prerequisite

Defined by curriculum of study program/module

learning resources

1. Levenspeil, O.: Chemical reaction engineering, serbian translation, Belgrade, 1991.
2. Вороњец, Д., Кубуровић, М.: Thermodynamics of multicomponent systems and chemical thermodynamics, Faculty of mechanical engineering, Belgrade, 1991.
3. Perry's Chemical Engineering Handbook, Mc-Graw Hill, 1999.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 20
laboratory exercises: 2
calculation tasks: 5
seminar works: 0
project design: 0
consultations: 3
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 3
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 7
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 25
laboratory exercises: 5
calculation tasks: 10
seminar works: 0
project design: 0
final exam: 50
requirements to take the exam (number of points): 28

references

Смирнов, Н.Н., Волжинскии, А.И., Химические реактори в примерах и задачах, Химија, Ленинград, 1986.
Coulson, J. M., Richardson, J. F.: Chemical Engineering, Vol. 3: Chemical Reactor Design, Biochemical Reaction Engineering including Computational Techniques and Control, Pergamon Press, Oxford, 1982.
Smith, J.M., Van Ness, H.C., Addott, M.M.: Chemical Engineering Thermodinamics, McGraw International Edition, ISBN: 0-07-240296-2, 2001.
Walas S. M.: Chemical Process Equipment, Selection and Design, Butterworth-Heinemann, 1990.

Combustible, technical and medical gases

ID: MSc-0511
teaching professor: Радић Б. Дејан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: process and environmental protection engineering

goals

The aim of this course is to familiarize students with the fuel characteristics, technical and medical gases, and to acquire academic skills and competencies for selection and calculation of equipment of gas installations. Through this course student mastery specific practical skills for work in the design and calculation of pipelines and fittings, storage tanks and other equipment for gas. Through laboratory student acquire knowledge related to testing of equipment for gas.

learning outcomes

Successful completion of the study program the student receives the following general skills: analysis, synthesis and forecasting solutions and consequences, and develop critical thinking and self-critical approach, application of knowledge in practice, professional ethics, linking knowledge from different fields and their applications, development of skill and dexterity in the use of knowledge in the field of distribution and transportation of natural gas storage and technical gases.

theoretical teaching

Natural gas, LPG, other fuel gases. Types and equipment for Gas Pressure Regulating Stations and Gas Pressure Regulating and Metering Stations. Types of devices for inner gas installations, safety equipment, removal of combustion products. Technical gases: air, atmospheric gases, hydrogen, chlorine... – characteristics and applications. Equipment of installations for storage and distribution. Production of atmospheric gases. Cleaning and preparation of installations. Gas bottles an tanks for gas storage, pilot regulators, gas pressure regulators, safety blow – off and relief valves, check valves, gas filters, heat exchangers, pipe insulating connections, control device accessories , odorizers , ball valves , electromagnetic valves, flow rate regulators, gas regulating and metering stations.

practical teaching

Gas composition, pressure drops, odorisation. Pipe sizing, level of security, material characteristics. Classification and elements of gas pipelines. Hydraulic calculation of gas pipelines. Gas pipeline equipment. Testing of installation of natural gas, LPG, other fuel gases and technical (industrial) gases. Calculation and sizing of equipment (pressure regulators, safety valves, apparatus...). Capacity of Gas Pressure Regulating Stations and Gas Pressure Regulating and Metering Stations. EN and ISO standards. Gas purification. Danger zones.

prerequisite

Defined by curriculum of study program/module.

learning resources

Given that for the subject has not yet completed a textbook, materials for lectures in printed and electronic form are given to students.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 20

active teaching (practical)

auditory exercises: 30
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 5
consultations: 5
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 3
colloquium, with assessment: 7
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 25
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 15
final exam: 50
requirements to take the exam (number of points): 28

references

M. Šunic, N. Dujmović: Gas and gas technique, 1981
S. Raketić: Gases, Technical gases – fuel gases, regulations and security measures, 1985.
Strelec, V: Gas manual, Nafta – Poslovna zajednica, Zagreb, 1982.
Bogner, M. i dr.: Termotehničar, part 2, Interklima-Grafika, Vrnjačka Banja, SMEITS, Belgrade, 2004.
Tanasković, P.: Crude oil and gas transport, part III – LPG, Nafta-Gas, Novi Sad, 1976.

Concepts of environmental and workplace protection

ID: MSc-0183
teaching professor: Јововић М. Александар
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 4
final exam: written
parent department: process and environmental protection engineering

goals

The main course objectives are related to introduce students to environmental problems, natural hazards and human impact on the environment. In order to solve problems, students will be acquainted with the physics and chemistry of the environment, atmospheric phenomena, the basics of microbiology and ecology.

learning outcomes

Based on lessons envisaged to overcome the students will be able to make independent decisions related to environmental management, sustainable development, impact assessment of projects and facilities on the environment. Especially important is the knowledge that students acquire in terms of life cycle analysis of products and processes.

theoretical teaching

Introduction, The changing role of technology, legislation and regulation; Technical basis-JUS ISO 14000; Importance and influence of public
The dilemma of industrialization and urbanization, The growth of the energy impact on the environment, Energy source impact on the environment
Classification and measurement of natural hazards, Greenhouse effect and ozone depletion, Acid rain;
Physics and chemistry of the environment, Particulate matter distribution, Solutions and solubility, Gases, gas mixtures, transport in the system of "gas-liquid" Material balance, Reaction, Reaction kinetics and reactors
Atmospheric science, Basic characteristics and balance, Air flow, atmospheric stability, turbulence, Water in the atmosphere, Climate; Prediction of air pollution concentrations
Microbiology and Ecology, Basic and applied microbiology, Epidemiology and disease, energy flows in ecosystems, food chains and trophic levels, Nutrient cycles, Elements of limnology, Eutrophication
Sustainable Development, EIA, RA and LCA; The strategy, Plans and Programs, Ethics.

practical teaching

The basic calculation of the positions of legislation, norms and standards,
The calculation of risk and hazard installations,
Calculation of episodic air pollution, Sample of inventory/cadastre of gases,
Example of impact assessment and risk assessment strategies, plans and programs, Elements of the product life cycle,
Modeling of particulate matter distribution, Solutions and solubility, Gases, gas mixtures, transport in the system "gas-liquid", Calculation of material balance,
Basic calculations of chemical reactions, reaction kinetics and reactors,
Calculating the energy balance of the atmosphere, basic concepts and calculations related to air flow, atmospheric stability, turbulence, water circulation in the atmosphere, meteorology, dispersion models, plume model,
The basic concept of ecology, energy flows in ecosystems, the basic calculations in

microbiology,
Development of simplified impact assessment study or preparation of LEAP,
Consultations during the project development,
Public presentation of papers and discussion.

prerequisite

There are no requirements to attend courses, in terms of the previously passed courses.

learning resources

Considering that for the course is not yet completed a textbook, materials for lectures are submitted to students in printed and electronic form.

number of hours

total number of hours: 45

active teaching (theoretical)

lectures: 18

active teaching (practical)

auditory exercises: 11
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 3
consultations: 2
discussion and workshop: 2
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 2
colloquium, with assessment: 0
test, with assessment: 2
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 10
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 10
final exam: 70
requirements to take the exam (number of points): 20

references

Kuburovic, M., Jovovic, A., et al., Zastita zivotne sredine (Chapter 15), p. 644-856., Termotehnicar, tom 2, 2004., ISBN 86-82685-03-5
Kiely, G., Environmental Engineering, McGraw-Hill, 1997.

Design, construction and operation of processing systems

ID: MSc-0363
teaching professor: Петровић Љ. Александар
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: process and environmental protection engineering

goals

Objective of the course is to introduce students to different stages of construction, from technical documentation preparation and obtaining the necessary approvals to construction and exploitation. Students learn about with the contents of the project. In the second part of the course acquire basic knowledge related to activities that follow design of processing industry facilities (power supply, operating fluids, transport, water flow etc.). Part of the course deals with the economic evaluation of investments.

learning outcomes

Main outcome of the course is to teach students to independently run object construction. This includes project documentation preparation and object construction. After successful completion of the study program, student is capable to foresee the extent of necessary design work in processing industry, as well as to plan necessary installation for production plants.

theoretical teaching

Legal framework for building facilities. Planning and Construction Law. Aim of design. Building capital investment facilities. Types of mechanical engineering projects. Content of a mechanical engineering project. Workplace safety. Fire protection. Environment protection. Assessment of impact on environment. Design of technology supported production line. Drawing schemes of technology systems and production systems. Marking of apparatus, valves, fittings and equipment for measuring and regulation on technological schemes. Technology warehouses and transport systems. Plants for energy supply. Basic forms of energy: heat (thermal), electrical and mechanical (potential and kinetic energy). Power systems. Operating fluids (water, air, technical gases).Distribution of water vapor. Compressed air and technical gases. Heating, air-conditioning and ventilation. Maintenance of production and technology systems. Assessment of services in building capital investment facilities. Investment costs. Feasibility study. Exploitation costs.

practical teaching

Introduction to the investment technical documentation. Introduction to the format of mechanical engineering projects. Examples of calculation of technology supported production lines. Examples of drawing technology systems schemes. Designing warehouses and transport systems. Power supply systems. Compressed air supply. Design of facilities for energy supply. Distribution of operative fluids. Budget and validation of investment. Exploitation and investment costs of facility operation. Independent realization of the main machine engineering project according to the predefined project task.

prerequisite

Defined with curriculum of study program / module

learning resources

Bogner M.: Design of thermotechnical and process systems, Third revised edition, Belgrade, 2007., KDA.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 20

active teaching (practical)

auditory exercises: 25
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 10
consultations: 5
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 5
colloquium, with assessment: 3
test, with assessment: 2
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 20
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 20
final exam: 50
requirements to take the exam (number of points): 30

references

Handouts
Perry's Chemical Engineering Handbook, Mc-Graw Hill, 1999.
Bogner M.: Design of thermotechnical and process systems, Third revised edition, Belgrade, 2007., KDA.

Draying and drayers

ID: MSc-0145
teaching professor: Јовановић М. Александар
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 4
final exam: written+oral
parent department: process and environmental protection engineering

goals

Students will be introduced to technical bases of materials drying process. The goal of this course is a review of the dryers basic constructions. Through this course students acquire skills and knowledge to recognize problems that occur in complex drying processes.

learning outcomes

Successful completion of the study program student acquires specific skills in function of quality performance of professional activities. It is anticipated that students acquire knowledge on specific technical solutions in the fields of drying materials, as well as being able to analyze complex technical solutions.

theoretical teaching

The definition of the drying process, classification, application and importance of processes and equipment for drying, the definition of basic parameters, measuring of mass moisture content.
Statics of the drying process,
Kinetics of the drying process,
Kinetics of convective drying of wet materials. The curves of drying kinetics, Experimental determination and aproach. The drying speed curves,
Design of dryers,
General settings in the design of drying, basic requirements for drying, dryers constructions and selection of accessories for drying; choice of drying agent and the heat carrier,
Balancing processes,
Material and energy balance of dryer, Theoretical and real drying, Graphical presentation of process in a dryer,
Heat balance calculaton of dryers,
Heat balance calculation of dryers using the "enthalpy-composition" and "enthalpy-temperature" diagrams; hot air and diluted exhaust gas drying and convective dryers efficiency,
Types and classification of dryers constructions,
Auxiliary dryers equipment,
Techno-economic indicators of dryers operation,

practical teaching

Basic terms and parameters,
Basic calculations in the drying processes,
The calculation of basic characteristics of wet air,
Calculation of material and energy balance,
Calculation of material and energy balance of theoretical and real dryer in hot air and diluted exhaust gas drying processes (drying agent flow, heat consumption, the coefficient of heat transfer, consumption of heated steam, plant efficiency)
Calculation of material and energy balance of theoretical and real dryier during the process of air preheating as a drying agent, as well as drying agent recirculating,
Selection and dimensioning of dryers,

Determination of drying thermograms (convective drying kinetics) in static-layer,
Determination of moisture adsorption of silica gel,
Determining the proportion of moisture in the exhaust flue gas ducts,
Development of technical documentation,
Preparation for development of technical documentation, Development of technical, (constructional) documentation: Selection and sizing dryers, equipment specifications and graphic documentation.

prerequisite

There are no requirements to attend courses, in terms of the previously passed courses.

learning resources

Considering that for the course is not yet completed a textbook, materials for lectures are submitted to students in printed and electronic form.
Preparation of book with examples conaining selection and sizing of equipment is underway.
Laboratory facility / installation / machine (LFI):
Laboratory dryer with auxiliary equipment,
Laboratory measurement system (LMS),
Equipment for determining proportion of moisture in the air,
Equipment for determining proportion of moisture in the flue and waste gases.

number of hours

total number of hours: 45

active teaching (theoretical)

lectures: 18

active teaching (practical)

auditory exercises: 11
laboratory exercises: 3
calculation tasks: 0
seminar works: 0
project design: 4
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 2
check and assessment of seminar works: 0
check and assessment of projects: 2
colloquium, with assessment: 0
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 0

laboratory exercises: 10
calculation tasks: 0
seminar works: 0
project design: 10
final exam: 70
requirements to take the exam (number of points): 20

references

Antic, M., et al.: Industrijske peci, in Termotehnicar, Poslovna politika, 1992.-стр.79-208

Efficiency of process end energy systems

ID: MSc-0399
teaching professor: Јанкес Г. Горан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 2
final exam: written
parent department: process and environmental protection engineering

goals

learning outcomes

theoretical teaching

practical teaching

prerequisite

learning resources

"Г.Јанкес, М.Станојевић, М.Каран, М.Стаменић: Индустријске пећи и котлови
приручник за вежбања са решеним задацима, Машински факултет, Београд, 2001.
Термотехничар, том 1 и 2, Пословна политика, Београд, 1992.
J.,Henri, Brunklaus, F. J. Stepanek: Industrieofen bau und betrieb, 5 Auflage, Vulkan Essen, 1986
Ан. Л. Бергауз и др. Справочник конструктора печеи прокатного пшроизводства, Том I и II, Металлургија, Москва 1970.
W. Heiligenstaedt Warmetechnishe Rechnungen fur Industrieofen, 4. Auflage, Verlag Stahleise4n M.B.H. Dusseldorf, 1966
Seam its generation and use, 41 Edition, Babcock and Wilcox, 2005.
"

number of hours

total number of hours: 30

active teaching (theoretical)

lectures: 0

active teaching (practical)

auditory exercises: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0

check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 0
final exam: 30

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 100
requirements to take the exam (number of points): 0

references

Equipment of process systems

ID: MSc-0333
teaching professor: Петровић Љ. Александар
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: process and environmental protection engineering

goals

Objective of the course is that students acquire academic skills and academic competencies for selection and calculation of strength of vessels, apparatus and equipment. By performing students' projects, they acquire creative and specific practical skills that qualify them to perform professional work in the field of process equipment design. Through the laboratory experiments and exercises, students gain knowledge of testing and exploiting process equipment.

learning outcomes

By successful completion of the study program student acquires the following skills: analysis, synthesis and prediction of solutions and consequences; development of critical thinking and self-critical approach; application of knowledge in practice; professional ethics; correlation of knowledge from different fields and their applications; development of skill and proficiency in the use of knowledge in field of process equipment.

theoretical teaching

1. Process equipment. Process equipment classification. 2. Loading types. Shell theory. 3. Cylindrical and spherical shells under internal pressure. 4. Dished ends. Reinforcement. 5. Classification and marking of pipelines. Input data for design. Description of activities in the design phase. Materials for pipelines. Graphical documentation. 6.Self-compensation, axial compensator, pipelines not laid in canals, selection and calculations. 7. Purpose and classification, plug valves (passing, three-way and four-way valves and ball valves) regulation characteristics. 8. Safety valves, safety valve's calculation and selection. 9.Valve functions, calculation and selection. 10. Vessels support. Support of horizontal and vertical apparatus. Pipeline support.

practical teaching

1. Pressure vessels classification. 2. Spherical and cylindrical shells. 3. Flanges. 4. Torispherical ends. Conical shells. 5. Calculating thermo isolation, selection of isolation type – characteristics of isolation materials. 6. Examples of calculating self-compensations with and without pre-stressing. 7. Dimensioning, materials and selection, sealing, fittings. 8. Safety valve dimensioning. 9. Examples of dimensioning, installing and selecting pressure regulating valves. 10. Vessel and pipeline supports.

prerequisite

Course for students have not listened items Pipeline and fittings and Mechanical Design of Process Equipment

learning resources

HANDOUTS,

Bogner,M.: Petrovic, A.: Pressure vessels, Bureau for textbooks and teaching tools, Belgrade, 2003.
Bogner, M.: Petrovic, A.: Pressure vessel design, SMEITS, Belgrade, 1991.
Bogner,M: Thermo technician, Interklima grafika, Vrnjacka Banja, 2004.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 20
laboratory exercises: 2
calculation tasks: 0
seminar works: 0
project design: 8
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 6
colloquium, with assessment: 4
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 20
laboratory exercises: 5
calculation tasks: 0
seminar works: 0
project design: 20
final exam: 50
requirements to take the exam (number of points): 30

references

Handouts
Bogner, M.: Petrovic, A.: Pressure vessel design, SMEITS, Belgrade, 1991.
Bogner,M.: Petrovic, A.: Pressure vessels, Bureau for textbooks and teaching tools, Belgrade, 2003.
Bogner,M: Thermo technician, Interklima grafika, Vrnjacka Banja, 2004.

Heat transfer operations and equipment

ID: MSc-0180
teaching professor: Јаћимовић М. Бранислав
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: process and environmental protection engineering

goals

Analysis of the heat transfer operations and apparatuses and assessment of their role in modern industry.
Understanding the most commonly used types of heat transfer apparatuses - their design and calculation procedures.

learning outcomes

The mastery of calculation procedures needed to analyze the heat transfer operations - the heat balance, determination of the operational line and driving force.
The mastery of calculation procedures for sizing of the most commonly used types of tubular, plate and contact heat exchangers.

theoretical teaching

Classification of heat transfer operations and aparatuses.
Working media in heat transfer operations.
General methodology of design of heat transfer operations and aparatuses.
Design methodology for recuperative heat exchangers.
Steady state heat exchange with counter-current, co-current and mixed flow paterns.
Tubular and plate heat exchangers: construction, calculation of heat transfer parameters and pressure drop.
Batch heat exchangers: clasification, heat performances.
Evaporation and evaporators
Contact heat exchangers

practical teaching

Examples of steady state recuperative heat exchangers with special reference to the sizing of most common types of tubular and plate heat exchanger (double pipe, shell-and-tube, plate exchangers)
Examples of batch heat exchangers (
Examples of evaporation and evaporators
Examples of contact heat exchanger (water cooling towers, barometric condensers)

prerequisite

learning resources

Jaćimović B., Genić S., Heat Transfer Operations And Equaipment, Part 1: Recuperative Heat Exchangers, Mašinski Fakultet Beograd, 2004.
Jaćimović B., Genić S., Mass Transfer Operations And Equipment, Part 1: Mass Transfer Basics, Mašinski Fakultet Beograd, 2007.
Jaćimović B., Genić S., Mass Transfer Operations And Equipment, Part 2: Mass Transfer

Operations, Mašinski Fakultet Beograd, 2010.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 30
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 10
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 60
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 21

references

Industrial furnaces and boilers

ID: MSc-0594
teaching professor: Радић Б. Дејан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: process and environmental protection engineering

goals

The goal of course is that students acquire the necessary skills to work on designing, maintenance and operation of industrial furnaces, and basic knowledge necessary for the maintenance and exploitation of industrial boilers. In addition to the courses students need to learn a methodology for energy balance and the basic principles of rational use of energy in industrial furnaces and boilers.

learning outcomes

A student shall be given the necessary skills to work on design and the organization of maintenance in industrial furnaces, and the planning of maintenance and operation of industrial boilers. They give a basis to work on projects for rational use of energy in industrial furnaces and boilers.

theoretical teaching

Definition and classification of furnaces and boilers. Elements of construction equipment and industrial furnaces. Energy Balances of industrial furnaces and description of the construction characteristics of industrial furnaces (furnaces for heating and melting of metals, nonmetals industrial furnaces, ovens in the food industry, etc). Application and description of the construction of industrial boilers. The characteristics of steam and hot water industrial boilers, boiler characteristic patterns and description of the construction, furnace and subsequent heating surface, the energy balance and efficiency. Testing of boilers.

practical teaching

Examples of certain types of industrial furnaces. The elements of construction equipment and industrial furnaces. Examples of material and energy balances of furnaces. Examples of energy balances of industrial boilers. Description and preparation of laboratory exercises: Measurement instruments and methodology, study the structure, organization of work on laboratory exercises. Preparation of project: Overview of project methodology, students divide into teams and assignment of project tasks. Laboratory: Measurement of energy losses in industrial furnaces in real operation: Students are divided into groups measure the parameters necessary for the calculation of energy losses in industrial furnaces in a selected company. Project design; students are divided into teams that work together project of given furnace.

prerequisite

Defined by curriculum of study program/module.

learning resources

Material from lecture – handouts.
Solution manuals, manuals for laboratory exercises, manuals for homeworks and seminar work.

Software for the calculation of the combustion process and the development of thermal balance of industrial furnaces and boilers.
Suplementary literature Termotehničar, volume 1 and 2, Poslovna politika, Belgrade, 1992. (volume 1 - chapters 3, 5 and 6, volume 2 - chapter 4)

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 18
laboratory exercises: 5
calculation tasks: 0
seminar works: 0
project design: 7
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 6
colloquium, with assessment: 0
test, with assessment: 4
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 20
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 20
final exam: 50
requirements to take the exam (number of points): 30

references

Termotehničar, volume 1 and 2, Poslovna politika, Belgrade, 1992.
G.Jankes, M.Stanojević, M.Karan, M.Stamenić: Industrial furnaces and boilers – solution manual, Faculty of Mechanical Engineering, Belgrade, 2001.
Baukal, C., The John Zink Combustion handbook, CRC company, 2001.
Ан. Л. Бергауз и др. Справочник конструктора печеи прокатного пшроизводства, volume I and II, Metallurgija, Moscow 1970.
Seam its generation and use, 41 Edition, Babcock and Wilcox, 2005.

Mass transfer operations and equipment

ID: MSc-0162
teaching professor: Јаћимовић М. Бранислав
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: process and environmental protection engineering

goals

Analysis of the mass transfer operations and apparatuses and assessment of their role in modern industry.
Understanding the most commonly used types of mass transfer apparatuses - their design and calculation procedures.

learning outcomes

The mastery of calculation procedures needed to analyze the mass transfer operations - the material balance, determination of the operational line and driving force.
The mastery of calculation procedures for sizing of the most commonly used mass transfer apparatuses.

theoretical teaching

Classification of mass transfer operations and basics principles of mass-transfer operations
General calculation procedure for mass transfer operations. Operation and equilibrium line, mass transfer driving force, number of transfer units, theoretical stage.
Mass transfer operations: distillation (continuous evaporation, single stage distillation, continuous condensation, distillation with deflegmation, differential distillation, fractional distillation, differential condensation), rectification, absorption, extraction, leaching, adsorption, drying.
Mass transfer apparatuses for gas-liquid systems, liquid-liquid and solid phase - fluid. Trayed and packed columns, drying chambers, etc.
Membrane mass transfer operations and and apparatuses.
Development trends in the field of mass transfer operations and apparatuses.

practical teaching

Examples of mass transfer operations. Mass and heat balancing. Determination of the operating line, driving force, the number of transfer units, the number of theoretical stages.
Examples of sizing of most commonly used mass transfer apparatuses: distillation column (with packing and with trays), extraction columns (with packing and with trays), adsorber (with a fixed layer of adsorbent), dryers (continuous and periodical).
Design procedures for membrane mass transfer operations and and apparatuses.

prerequisite

learning resources

Jaćimović B., Genić S., Heat Transfer Operations And Equaipment, Part 1: Recuperative Heat Exchangers, Mašinski Fakultet Beograd, 2004.
Jaćimović B., Genić S., Mass Transfer Operations And Equipment, Part 1: Mass Transfer Basics, Mašinski Fakultet Beograd, 2007.
Jaćimović B., Genić S., Mass Transfer Operations And Equipment, Part 2: Mass Transfer

Operations, Mašinski Fakultet Beograd, 2010.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 30
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 10
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 60
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 21

references

Measurements and Control in Process Industry

ID: MSc-0403
teaching professor: Станојевић М. Мирослав
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: process and environmental protection engineering

goals

Introducing the candidate with the principles of process measurement and control of the process using the measured values. After the course candidates will be capable to independently perform statistical processing of measurement results and evaluation of measurement uncertainty. The process of accreditation of laboratories and regulatory organizations.

learning outcomes

Upon completion of the course is expected that the candidate is familiar with the basic measurements and instruments used in measurement and control in process systems. Also it is expected that the student is able to independently plan experimental measurements and work in laboratory and also to evaluate the measurement uncertainty. Basic knowledge about the accreditation of laboratories candidate receives through the consideration of the basic requirements of relevant standards.

theoretical teaching

Basic concepts of measurement and control in the process industry. Basic measurements in the process industry. Temperature measurements. Measurement of pressure and pressure differences. Measurement of fluid flow. Types and operating principles of sensors. Other measurements in process industry: weight, level, concentration, humidity, fluid physical properties (density and viscosity). Determination of the composition of gases and concentration of particulate matter. Complex measurement systems with data acquisition. Analog and digital signals. Transferring data to a computer. The formation of the control algorithm. Basic principles of operation of the SCADA software. Application of PLC's control. Measurement error. Statistical analysis of measurement results. Traceability of measurements. Calibration of measuring instruments. The concept and method for determining measurement uncertainty. Metrology laboratories and laboratories for testing and callibration. Methods and requirements for achieving the technical competence of laboratories accredited according to SRPS ISO/IEC 17025:2006 and SRPS ISO/IEC 17020:2002

practical teaching

Examples of certain measuring devices, devices for data acquisition and control. The realization of individual measurements in the laboratory (practical laboratory work).
Processing of measured data and values and estimation of measurement uncertainty.
The physical basis of determination of the measured values. Mathematical expressions that describe the phenomena that are used to process measurements. Methods of temperature measurements, pressure and pressure difference, flow metering using orifice plate, speed measurements of gases analysis. Complex systems of measurement and control of process systems. Methods for determining the measurement uncertainty. The process of laboratory accreditation.

prerequisite

The subject is optional. No special requirements for attending the case.

learning resources

1. Laboratory installation for pressure and temperature measurements (manometers, inclined manemoter, pressure transmitters, U-tube, thermocouples, thermometers, acquisition system),), Laboratory for Process engineering (room 6.
2. Apparatus for flow measurement (orifice plate, Pitot tube, anemometers),), Laboratory for Process engineering (room 6.
3. Analysers for emission monitoring (gas analysers and equipment for emission measurements of particulate matter), Laboratory for Process engineering (room 6.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 17
laboratory exercises: 13
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 5
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 5
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 20
laboratory exercises: 30
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 40
requirements to take the exam (number of points): 30

references

Mechanical and hydromechanical Operations and Equipment

ID: MSc-0292
teaching professor: Станојевић М. Мирослав
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: seminar works
parent department: process and environmental protection engineering

goals

The purpose of subject is for students to get knowledge about mechanical and hydromechanical processes and equipment. Through the semester students' projects, students get creative and specific practical skills for construction of process equipment. The laboratory exercises have the aim to give appropriate knowledge to students about examination of process equipment during the production as well as the exploitation process.

learning outcomes

After successful course attending students get ability for: analysis, synthesis and predicting solutions and consequences; developing of critic and self critic thinking and approach; practical knowledge implementation; professional ethic; connecting knowledge from different subjects and their implementation; developing skills and abilities for knowledge implementation in adequate area.

theoretical teaching

1. Introduction to mechanical operations, 2. Basics of particle size reduction processes (Energy consumption), 3. Crushing and crushers, 4. Grinding and grinders, 5. Typical flow sheets for size reduction processes, 6. Screening, 7. Mixing of solids (types of mixing equipment), 8. Mechanisms of dust collection, 9. Types and performances of dust collectors, 10. Filtration processes and equipment.

practical teaching

1. Particle size distribution, degree of particle size reduction, 2. Energy consumption for size reduction, 3. Crushing, 4. Grinding, 5. Screening, 6. Laboratory exercise: Screen analysis of solid particles sample with laboratory grinding and screening equipment, 7. Mixing of solids, 8. Gas-solids and liquid-solids separations, 9. Cyclone separators (Determination of cyclone collection efficiency), 10. Example of calculation and design of equipment for dust colection.

prerequisite

Elective course. There is no specific requirement for course attending.

learning resources

1.Bogner, M.: Mechanical operations, Naučna knjiga, Beograd, 1987.
2.Laboratory grinding and screening equipment, Laboratory of process technique (room 6), LPI

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 19
laboratory exercises: 2
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 9
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 1
check and assessment of seminar works: 3
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 6
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 45
laboratory exercises: 5
calculation tasks: 0
seminar works: 15
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

Magdalinović, N.: Fragmetation and classification, Naučna knjiga, Beograd, 1991.
Bogner, M. at all.: Handbook of thermal technique, Interklima grafika, Vrnjačka Banja, 2003
Bogner, M., Stanojević, M., Livo, L.: Cleaning and filtration gas and liquid, ETA, Beograd, 2006.

Process Energetics

ID: MSc-0589
teaching professor: Јовановић М. Александар
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 2
final exam: written
parent department: process and environmental protection engineering

goals

Objective of this course is that students master basic skills of energy use in the industry in order to to adequately deal with the practical matters of rational use of energy and maintenance of energy equipment and systems in industrial companies. In addition, basic knowledge of the transformation and energy use are essential for the understanding of matter from other subjects of process engineering and environmental protection.

learning outcomes

Understanding the operation of energy equipment and technologies and principles of their rational use; making the energy balance of industrial enterprises and implementation of methodology for defining the energy losses of equipment and installations in industrial plants.

theoretical teaching

AT-1: Energy, energy transformation and usage of the energy in production processes in industry (general concepts about energy and energy resources, an overview of energy consumers and energy systems in industrial plants, energy balances of companies).
AT-2: Energy resources in industrial companies (power supply of industrial plants, boilers and boiler rooms, the combined heat and power production of in industry, energy requirements of production processes).
AT-3: Use of fuels in industry (Distribution of fuel and combustion systems, combustion and basics of combustion efficiency).
AT-4: Steam as a carrier of energy (steam characteristics, processes and equipment that uses steam in the process industry; description of distribution systems for steam and condensate return).

practical teaching

PA-1 # Preparation of energy balance (methodology of collecting data on energy consumption in industrial companies; examples of energy balance of selected companies).
PA-2 # Review of process energy systems and calculation of efficiency (power supply of industrial plants, boilers and boiler rooms, the combined heat and power production of in industry, energy requirements of production processes)
PA-3 Calculation of energy losses in distribution systems for steam and condensate return (steam quantity used for the production process; calculation of energy losses through the pipeline walls; calculations of energy loss in case of improper drainage of condensate)
PA-4 # Calculations of energy losses in industrial equipment that use the fuel (e.g. calculation of the combustion process, enthalpy-temperature diagrams, calculation of energy losses with the flue gases)
PS-1 # Preparation of the seminar work - Energy Audit in Selected Industrial Company (students doing their paper work and calculation, with the help of an assistant preparing written report on energy audit within one selected industrial company and power point presentation).

prerequisite

There are no requirements to attend courses, in terms of the previously passed courses.

learning resources

Selected chapters form Industrial furnaces and boilers - manual with solved examples (chapters 1, 2 and 3),
Lecture layouts,
Guidelines for solving problems, guidelines for preparation of reports on laboratory work, guidelines for preparation of seminar work,
Additional literature - Brochures and Newsletters in edition of Serbian Industrial Energy Efficiency Network (SIEEN).

number of hours

total number of hours: 30

active teaching (theoretical)

lectures: 8

active teaching (practical)

auditory exercises: 9
laboratory exercises: 0
calculation tasks: 0
seminar works: 6
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 2
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 30
project design: 0
final exam: 60
requirements to take the exam (number of points): 35

references

G, Jankes, M., Stanojevic, M., Karan, M.,Stamenic: Industiral furnaces and boilers - manual with solved examples ,Faculty of MEchanical Engineering, Belgrade, 2001.
Baukal, C., The John Zink Combustion handbook, CRC company, 2001.
G.,Jankes, M., Stamenic: Energy efficiency improvements in energy produciton in industrial boilers, SIEEN, 2007.
G.,Jankes, M., Stamenic: New combustion system, SIEEN, 2007.

Skill practice M - PTH

ID: MSc-0499
teaching professor: Станојевић М. Мирослав
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 1
final exam: written+oral
parent department: process and environmental protection engineering

goals

The goal of course is to acquaint students with the resources, machines and devices used in various industries, especially in the food and pharmaceutical industry, chemical industry, oil refining, gas, non-metals and building materials, metallurgy, energy, communal activity. The practice should enable students to easily master the subject matter of vocational subjects.

learning outcomes

The successful completion of course students are introduced to: 1.processes and equipment used in the processing industry, 2. designing methods of processing plants, 3. test methods of processing plants and equipment, and others.

theoretical teaching

The role and importance of professional practice - process engineering, engineering in environmental protection. Basic principles of devices and machines of process equipment. Fundamentals of technological processes in the field of process engineering. The basics of designing process systems. The basics of distributions main and auxiliary fluids.

practical teaching

Organization and visits to factories of process industries. Understanding the specific technological processes and equipment in process industries through a review of technical documents and examining the situation in the factories. Analysis of technical documents (project and technical documentation) in the process industries.Technical control (audit) of technical documents - from compliance with documentation requirements of regulations and standards in the field of process industries. Introduce students to the measuring equipment used in the process industry by direct insight into condition of this equipment in factories and laboratories at its disposal department. The role of process engineers in the design and implementation of systems management processes and technologies.

prerequisite

Obligatory subject of elective module Process engineering and environment protection.

learning resources

Literature published by members of the Department of Process Engineering. Technical documentation. Cataloging documentation.

number of hours

total number of hours: 46

active teaching (theoretical)

lectures: 0

active teaching (practical)

auditory exercises: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 0
final exam: 46

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 0
laboratory exercises: 30
calculation tasks: 0
seminar works: 30
project design: 0
final exam: 30
requirements to take the exam (number of points): 25

references

Technical regulations

ID: MSc-0622
teaching professor: Петровић Љ. Александар
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 2
final exam: written
parent department: process and environmental protection engineering

goals

Objective of the course is that students acquire academic skills and academic competencies for application of technical regulations. Through teaching activities student acquires creative skills and master specific practical skills for carrying out professional tasks - design in general.

learning outcomes

By successful completion of the study program student acquires the following skills: analysis, synthesis and prediction of solutions and consequences; development of critical thinking and self-critical approach; application of knowledge in practice; professional ethics; correlation of knowledge from different fields and their applications; development of skill and proficiency in the use of knowledge in field of technical documentation.

theoretical teaching

1. Technical regulations - laws, directives and standards. Types of projects as part of technical documentation. 2. Construction procedures from building approval, preparation, constructing, supervision and exploitation permit. Parts of project. 3. Accreditation. Testing laboratories, inspection bodies and certification bodies. Quality system. 4. Basis for creation of regulations and standards in terms of content and enforcement powers. Adoption of European and world standards (EN, ISO). Inspections and professional competence.

practical teaching

1. Legal obligations on main project summary - elaboration of individual chapters. 2. Creation and summary of general and technical requirements by type of project and summary. 3. Designer obligations during preparation of technical documentation regarding fire and explosion protection. Creation of annexes that are obligatory in technical documentation. 4. Regulations that apply all professions - supervision, construction, technical control. Conformity assessment. 5. Examples of directives related to technical issues. 6. CE marking. 7. Public presentation and presentation design. The content of written documentation (letters, proposals, contracts ...).

prerequisite

No previous conditions

learning resources

Handouts,
Isailovic, M., M. Bogner: Regulations on Planning and Construction, 6 expanded edition, ETE, Belgrade, 2006. ;
Bogner M.: Design of thermotechnical and process systems, Third revised edition, ETA, Belgrade, 2007., .
Bogner, M.; P. Zekonja, D. Ivanovic: Manual for project documentation creation, ETA,

Belgrade, 2007.;
Bogner, M., M. Stanojevic: About waters, ETA, Belgrade, 2006.
Isailovic, M.: Technical regulations on fire and explosion protection, Second edition, SMEITS, Belgrade, 2002

number of hours

total number of hours: 30

active teaching (theoretical)

lectures: 8

active teaching (practical)

auditory exercises: 14
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 2
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 4
test, with assessment: 0
final exam: 2

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 20
laboratory exercises: 0
calculation tasks: 0
seminar works: 20
project design: 0
final exam: 50
requirements to take the exam (number of points): 0

references

Handouts
Isailovic, M; Bogner, M.: Regulations in planning and constructions, ETA, Beograd, 2006.
Bogner, M., Zekonja, P., Ivanovic, D.: Manual for the project documentation, ETA, Beograd, 2007.

Waste and wastewater management

ID: MSc-0125
teaching professor: Јовановић М. Александар
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 4
final exam: written+oral
parent department: process and environmental protection engineering

goals

In this course, students will gain a solid basic and specific knowledge in the field of waste management and wastewater management. Laboratory exercises give students the opportunity to solve the various practical problems and perceive gained theoretical knowledge.

learning outcomes

Knowledge that students acquired about the specific technical solutions, the choice of methods of use waste and wastewater treatment equipment enabling the assessment of basic principles relevant for the design of these plants.

theoretical teaching

Characteristics, management, Legal basis and strategy, Systems of collection, Separation and treatment, Incidence and equipment for waste collection, transfer stations, transport, separation at source, recycling,
Thermal processing procedures, a biological waste treatment products using waste processing, Criteria for disposal, problems, control and treatment of leachate, generation and use of landfill gas, waste management future - legislation, collection, incineration, disposal,
Hazardous waste, remediation of contaminated soil,
Water resource management, Technological (process) characteristics, Planning, Legislation, Political influences, Future challenges,
Water demands, Requirements for water quality, Sources of water supply, Water treatment, Transfer (transport), distribution and storage of water, needs and future development,
Water pollution, Waste water collection, Treatment principles, Treatment plants,
Role of public and government in controlling pollution, Trends in controlling water pollution.

practical teaching

Calculation of the waste growth, determining the required capacity for the collection, calculation of waste composition,
Selection and sizing of equipment for waste treatment,
Selection and sizing of equipment for the factory for processing of municipal solid waste,
Determining the basic size of the landfille and landfill gas generation calculations and possibility of its using,
Calculation of concentration and flow of pollutants in and efficiency of equipment for the wastewater treatment,
Calculation of material and heat balance of devices for wastewater treatment and calculation of characteristic values,
Selection and sizing of equipment for wastewater treatment,
Examples of plants for biological wastewater treatment,
Experimental determination of heat and material balance of devices for pyrolysis of waste,
Determining the effectiveness of the air distributor in the aeration devices for biological wastewater treatment.

prerequisite

There are no requirements to attend courses, in terms of the previously passed courses.

learning resources

Considering that for the course is not yet completed a textbook, materials for lectures are submitted to students in printed and electronic form.
Laboratory facility / installation / machine (LFI):
1. Laboratory testing facility for wastewater treatment
2. Laboratory plant for thermal waste treatment

number of hours

total number of hours: 45

active teaching (theoretical)

lectures: 18

active teaching (practical)

auditory exercises: 13
laboratory exercises: 5
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 2
check and assessment of lab reports: 2
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 0
laboratory exercises: 20
calculation tasks: 20
seminar works: 0
project design: 0
final exam: 50
requirements to take the exam (number of points): 27

references

Kuburovic, M., Jovovic, A., et al., Zastita zivotne sredine, chapter 15, p. 644-856., Termotehnicar, tom 2, Interklima, SMEITS, 2004., ISBN 86-82685-03-5
Jovovic, A., Karan, M., Petrovic, A.: Process and equipment in waste treatment systems, in: Developments of equipment in process and environmental engineering, 2000., p. 97-122, ISBN 86-7083-385-9
Stanojevic, M., Simic, S., Radic, D.,Jovovic, A, Аерација отпадних вода, теорија и прорачуни, ETA, Beograd, 2006., ISBN 86-85361-07-9

Transport phenomena in process industry

ID: MSc-0276
teaching professor: Гекић Б. Србислав
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: process and environmental protection engineering

goals

Acquiring the necessary knowledge to understand the transport phenomena of heat and mass transfer in the process industry.
Application of steady and unsteady heat and mass transfer in phases (two or more component fluids) in process equipment.

learning outcomes

The understanding of fundamentals of heat and mass transfer processes accompanied with multiphase fluid flow.
Estimaption procedures for the intensity of heat and mass transport and pressure drop in chemical engineering.

theoretical teaching

Molecular transport phenomena. Newtons law of fluid friction, Fouriers law of heat conduction, Ficks law of molecular diffusion.
Steady and unsteady state heat and mass transfer in fluids.
Differential equations of of momentum, heat and mass convective transport. Laminar and turbulent flow.
Simplified models of convective transport. Analysis of heat and mass transfer resistances.Coefficients of Heat and mass transfer.
Similarity theory. Analogies between mass, heat and momentum transfer.
Mass transfer across a phase boundary. Interphase turbulence.
Simultaneous mass and heat transfer. Wet-bulb temperatures
Boiling, condensation and thermal radiation. Typical cases in process equipment (heat exchangers, columns, furnaces).
Unsteady heat and mass transfer in solid phase.

practical teaching

Examples of steady and unsteady state molecular transport in fluids and solids
Examples of convective transfer.
Examples of application of the similarity theory - criterial equations
Examples of heat and mass transfer across a phase boundary.
Examples of simultaneous heat and mass transfer.
Laboratory: Wet-bulb temperature, coefficient of molecular diffusion
Examples of heat transfer with phase change: boiling, condensation
Examples of thermal radiation.
Examples of the unsteady heat and mass transfer in solid phase.

prerequisite

learning resources

Jaćimović B., Genić S., Heat Transfer Operations And Equipment, Part 1: Recuperative Heat Exchangers, Mašinski Fakultet Beograd, 2004.
Jaćimović B., Genić S., Mass Transfer Operations And Equipment, Part 1: Mass Transfer Basics, Mašinski Fakultet Beograd, 2007.
Jaćimović B., Genić S., Mass Transfer Operations And Equipment, Part 2: Mass Transfer Operations, Mašinski Fakultet Beograd, 2010.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 25
laboratory exercises: 5
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 10
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 60
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 21

references

production engineering

Assembly systems
Axiomatic methods
Computer Control and Monitoring in Manufacturing Automation
Computer Integrated Manufacturing Systems and Technology
Computer Integrated Systems and Technologies
Computer Simulation in Manufacturing Automation
Computer Simulation in Manufacturing Automation
Coordinate Measuring Machines
Decision-making methods
Expert Systems
Industrial robots
Intelligent manufacturing systems
Machine tools M
Manufacturing Automation
Manufacturing Systems Design
Mechatronics systems
Micro Manufacturing and Characterization
Micro-nano Engineering Basics
New generation of machine tools and robots
New Technologies
PRODUCTION INFORMATION SYSTEMS
Project Management
Quality Management
Quality System and Integrated Managemet Systems
Sheet-Metal Processing Tools
SKILL PRAXIS M – PRO

Assembly systems

ID: MSc-0319
teaching professor: Петровић Б. Петар
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: production engineering

goals

1. Learning of systematic approach to the design and production of mechanical assemblies;
2. Understanding assembly process and basic assembly operations;
3. Impact of assembly process on product development – product structure and Design For Assembly techniques;
4. Part mating process, modeling and understanding relationships between precision, sensitivity and flexibility;
5. Basic concepts of assembly systems – manual, automatic and robotic systems; Assembly system design. Assembly workstation design issues;
6. Performance and Economics of Assembly Systems;
7. Product lifecycle and product disassembly.

learning outcomes

1. Understanding what is assembly, its role in production systems, and why it is important.
2. Fundamental knowledge and engineering skills about: assembly sequence analysis and design of assembly process, design of automatic part feeding and orienting, design for assembly (DFA) techniques, dimensioning and tolerancing of parts and assemblies, design of manual and automatic assembly workstations and systems, product disassembly and its impact on product lifecycle design.

theoretical teaching

Theoretical background of industrial assembly systems is given through 10 lectures + introductory lecture:
0. What is industrial assembly and its role in production systems,
1. Assembly system structure and assembly process,
2. Part mating theory of compliantly supported rigid parts,
3. Joining techniques and processes,
4. Feeding and material flow in assembly system,
5. Assembly structure, sequencing and Design For Assembly,
6. Manual assembly systems,
7. Automatic assembly systems – rigid transfer lines,
8. Automatic assembly systems – flexible assembly lines and robotic assembly cells,
9. Performance and Economics of Assembly Systems, and
10. Product lifecycle and disassembly technology.

practical teaching

Practical training is organized through laboratory exercises and project (team work) of assembly system design for selected product.
LAB 1: Quasi-static part mating – demonstration of passive compliant device RCC, demonstration of 6 DOF force/torque sensor, force sensor calibration, robot motion programming, measurement of part mating forces and identification of contact situations, comparison of experimentally evaluated results with theory.

LAB 2: Passive systems for feeding and orienting – vibratory bowl feeder and linear feeding tracks demonstration, part geometry analysis and identification of basic natural resting states, design and obstacles optimization of passive orienting system for selected class of headed cylindrical parts, tuning the system, measurement and efficiency estimation of configured orienting system, estimating of mean feeding capacity.
LAB 3: Vision systems for part feeding - demonstration of vision system configuration and its use in part feeding, image analysis and identification of paths contours and its locations, identification of system performances and optimization.
Project covers following topics: 1. Assembly design and product design for assembly (DFA), 2. Parts presenting systems - orientation, separation and positioning task, 3. Working heads for part mating, part joining and other assembly operations, and 4. Transfer systems - assembly conveying, manipulation operations, line balancing and control.

prerequisite

Fundamental knowledge on Manufacturing and Production Systems, Factory Automation, Robotics, Control Engineering

learning resources

[1] Petrović, P.B. 1998. Intelligent assembly systems - A contribution to the theory of assembly process, Book series of Intelligent technological systems, FME, Belgrade /In Serbian/;
[2] Handouts /In Serbian/;
[3] Instructions for laboratory report writing /In Serbian/;
[4] Instructions and project example /In Serbian/
[5] Instructions for handling the laboratory equipment /In Serbian/.
[6] Robotic cell equipped with sensory and acquisition system for demonstration of compliant part mating and RCC working principle;
[7] Experimental system based on linear vibratory conveyor for demonstration and students training in design of passive part presenting systems;
[8] Robotic welding system for demonstration of assembly joining operations based on welding and similar processes;
[9] Vision system for demonstration and students training in designing of flexible robotic part presentation systems;
[10] Experimental installation for demonstration of modern adhesion based joining technology (LOCTITE).

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 6
laboratory exercises: 6
calculation tasks: 0
seminar works: 0
project design: 16
consultations: 2
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 2
check and assessment of seminar works: 0
check and assessment of projects: 2
colloquium, with assessment: 0
test, with assessment: 6
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 25
laboratory exercises: 10
calculation tasks: 0
seminar works: 0
project design: 15
final exam: 40
requirements to take the exam (number of points): 30

references

Ćosić., I., Montažni sistemi, IP Nauka, Beograd, 1991, ISBN: 86-7621-045-4.
Boothroyd, G. 1983. Design for Assembly Handbook, Design project, Dep. Of Mechanical Eng., University of Massachusetts, Amherst, Massachusetts, USA.
Bothroyd, G., Poli, C. and Murch, L. E. 1982. Automatic Assembly, Marcel Dekker Inc., New York, USA, ISBN 0-8427-1531-4.
Whitney, E., D., Mechanical Assemblies: their Design, Manufacture, and Role in Product Development, Massachusetts Inst. of Techn, New York Oxford, OXFORD UNI PRESS, 2004, ISBN 0-19-515782-6
Nof, S. Y., Wilhelm, W. E. and Warnecke, H. J. 1996. Industrial Assembly, Chapman & Hall, London, GB, ISBN 0-412-55770-3.

Axiomatic methods

ID: MSc-0285
teaching professor: Бабић Р. Бојан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: project design
parent department: production engineering

goals

Course aim is to scrutinize the design process in its entirety, from problem definition to conceptualization to embodiment and realization, in a discipline-independent framework, with the purpose of gaining insight into the process from the most general viewpoint.

learning outcomes

Advanced application of axiomatic design theory for design of products, manufacturing processes and manufacturing systems. Ability for structuring and decomposing designs in order to systematically apply design axioms. Advanced application of design software. Teamwork abilities.

theoretical teaching

Analytical methods in engineering design. Methodology of engineering design. Axiomatic approach in design. Basics of axiomatic design. Creativity and axiomatic design. Concept of domains. Problem definition and functional domains. Mapping process and its graphic interpretation. Design decomposition. Design for manufacturing. Information axiom and its implications. Manufacturing process planning and information content. Axiomatic design of products. Case studies of designs made by application of axiomatic design theory. Axiomatic design of manufacturing systems. Axiomatic approach to design of software. Ergonomics and axiomatic desing. Cost engineering in axiomatic design. Theory of inventive problem solving - TRIZ.

practical teaching

Examples of application of analytic design methods. Axiomatic design of products, processes and systems. Application of axiomatic design in manufacturing domain. Defining functional requirements for manufacturing system. Design for manufacturing, design of manufacturing processes and intelligent machines. Intelligent system for design of manufacturing systems. Project and consultations about project. Software packages for axiomatic design. Examples of making designs based on ergonomics. Discussions and workshops.

prerequisite

Defined by curriculum of study programme/module.

learning resources

(2) I-TRIZ Innovation WorkBench – a comprehensive software tool for inventive problem solving.
(3) I-TRIZ Ideation Brainstorming – a simplified tool for solving problems of light to medium complexity.
(4) Axiomatic design software

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 0
laboratory exercises: 8
calculation tasks: 3
seminar works: 0
project design: 15
consultations: 4
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 4
colloquium, with assessment: 2
test, with assessment: 4
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 15
test/colloquium: 20
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 35
final exam: 30
requirements to take the exam (number of points): 30

references

B. Babic, FLEXY–INTELLIGENT EXPERT SYSTEM FOR FMS DESIGN,Intelligent Manufacturing Systems Series,Book 5, University of Belgrade, Faculty of Mechanical Engineering,1994,18.1
N. P. Suh, (1990) THE PRINCIPLES OF DESIGN, Oxford University Press, New York
G. J. Park, (2007) ANALYTIC METHODS FOR DESIGN PRACTICE, Springer Verlag, London

Computer Control and Monitoring in Manufacturing Automation

ID: MSc-0218
teaching professor: Пилиповић Д. Мирослав
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: production engineering

goals

Acquisition of knowledge about the application, design and introduction of modern computer control systems and supervisory into manufacturing automation. Skill development for solving computer control nad supervisory problems by using computer, information and control technologies and adequate scientific methods.

learning outcomes

The student should:
1. Uderstand the principles, place and role of the computer control system and supervisoring in manufacturing automation, link knowledge of related subjects to apply it to control and supervisoring in manufacturing automation;
2. Master scientific methods of analysis, synthesis, design and introduction of computer control systems in manufacturing automation;
3. Know practical problem-solving and how to apply computer technology and modern control systems in control and supervisoring in manufacturing automation.

theoretical teaching

1.Computer control systems in manufacturing automation. CNC, robot controllers, programmable controllers, programmable automation controllers and computers.
2. CNC control. Functions, hardware, software, mathematical models. Main and auxiliary movement control, interpolation and internal calculations. Control panel and workshop programming. Communication functions.
3. Programmable controllers. Functions, hardware, software, input/output modules. Programming languages and programming techniques according to the IEC 61131 standard. 4. SCADA systems. Functions, hardware, software. Data acquisition, man-machine interface, programming and algorithms in control and monitoring.
5. Sensors and actuators in control and supervisoring. Remote and intelligent terminal units.
6. Modern computer control systems and open-architecture control systems. Communication networks. Distributed control systems in manufacturing automation and IEC 61499.

practical teaching

1.Auditorial exercises: Tasks in control design and supervisoring in manufacturing automation, with programming and control scheme design.
2. Laboratory exercises: Design of examples for control and supervisoring in manufacturing automation and their practical realization in laboratory conditions, with the use of modular robots and computer-based control systems, CNC control, programmable controllers, robot controllers and SCADA software, with programming.
3. Project: Design of examples for control and supervisoring in manufacturing automation, with programming.

prerequisite

Defined by curriculim of study program.

learning resources

1. Pilipović, M. Control and monitoring in manufacturing automation - Handouts, FME, Belgrade, 2011, DVL
2. Pilipović M., Manufacting processes automation: Laboratory, FME, Belgrade, 2006, PRA. /In Serbian/
3. Lab desk with pneumatic, electro-pneumatic and electric components and programmable controllers, Lab for manufacturing automation, EOP/LRS.
4. "Pick and Place" electro-pneumatic modular robots with programmable controllers, Lab for manufacturing automation, EOP/LPI.
5. Programming computers, Lab for manufacturing automation, IKT/PPC.
6. Software for programmable controller programming, Lab for manufacturing automation, IKT/RRO.
7. Communication network of computers and programmable controllers, Lab for manufacturing automation, IKT/KIO.
8. CNC and robot controllers, Lab for machine tools, EOP/LPI
9. SCADA software for supervisoring and programming, Lab for manufacturing automation, IKT/RRO.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 8
laboratory exercises: 10
calculation tasks: 0
seminar works: 0
project design: 10
consultations: 2
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 4
check and assessment of seminar works: 0
check and assessment of projects: 2
colloquium, with assessment: 0
test, with assessment: 4
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 20
laboratory exercises: 15
calculation tasks: 0

seminar works: 0
project design: 20
final exam: 40
requirements to take the exam (number of points): 36

references

Mikell P. Groover, Automation, Production Systems, and Computer Integrated Manufacturing, Prentice-Hall, Inc. 1987.
David Bailey, Edwin Wright, Practical Scada for Industry, Esevier, 2003.
Yoram Koren, Computer Control of Manufacturing Systems, McGraw-Hill Book Company, 1983.
Informatika: INFO 73 Programmable Controllers, Programming Guide, Informatika, Belgrade, 2011.
Informatika, InfoControl SCADA - User Guide, Informatika, Belgrade, 2011.

Computer Integrated Manufacturing Systems and Technology

ID: MSc-0665
teaching professor: Бабић Р. Бојан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: production engineering

goals

A detailed study of the principles and application of computer integrated manufacturing. Advanced concepts and models related to computer-aided design, computer-aided process planning, computer aided manufacturing, production planning and scheduling.

learning outcomes

This course will enable the student to:
1. Explain basic concepts of CIM systems
2. To gain knowledge on how computers are integrated at various levels of planning and manufacturing.
3. Develop machining programs for CNC equipment
4. Design CIM systems to fulfill certain requirements
5. Identify and solve problems in the operations of CIM systems
6. Enhance performance of manufacturing systems by applying different CIM concepts and tools
7. To understand the flexible manufacturing system and to handle the product data and various software used for manufacturing

theoretical teaching

1. Introduction to CIM
2. Computer-aided Design
3. Automated Manufacturing Equipment
4. Group Technology And Computer-aided Process Planning
5. Shop Floor Control and Introduction of FMS
6. Production Planning and Control
7. Cim Implementation and Data Communication

practical teaching

Laboratory work includes computer-aided applications and programming of automated production equipment.

prerequisite

Defined by curriculum of study programme/module.

learning resources

(1) B. Babic, FLEXY–INTELLIGENT EXPERT SYSTEM FOR FMS DESIGN,Intelligent Manufacturing Systems Series,Book 5, University of Belgrade, Faculty of Mechanical Engineering,1994
(2) B. Babic, Software "Moodle" for distance learning (http://147.91.26.15/moodle/), University of Belgrade, Faculty of Mechanical Engineering, 2012

(3) AnyLogic simulation software
(4) B. Babic, Software packages for process planning
(5) B. Babic, Process planning, University of Belgrade, Faculty of Mechanical Engineering, 2006

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 0
laboratory exercises: 8
calculation tasks: 3
seminar works: 0
project design: 15
consultations: 4
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 4
colloquium, with assessment: 2
test, with assessment: 4
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 15
test/colloquium: 20
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 35
final exam: 30
requirements to take the exam (number of points): 30

references

Groover, M. P., Automation, Production Systems, and Computer-Integrated Manufacturing, 3rd Ed. Pearson Education, 2008

Computer Integrated Systems and Technologies

ID: MSc-0191
teaching professor: Спасић А. Жарко
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: production engineering

goals

Integration of computerized digital enterprise activities. Information integration of the company. Functional integration of the company. Integration of knowledge in all subjects from department. Connectivity of hardware and software components of production-business systems. Managing complex systems in industry. Application of new IC technologies. Choice for final paper and employment.

learning outcomes

Understand the effects of work in integrated enterprise systems and technologies. Linking knowledge and skills from other subjects of department. Apply new IC technologies. Critically evaluates the production-business systems and technology. Keep business conversations. Design and modifies the computerized systems. Competence for the integration of hardware and software. Participate in project teams.

theoretical teaching

Integration of production, information, communication and educational technologies. Reference, partial and particular models. The concepts of academic institutions and leading industries. Framework model of information integration. Integration of engineering, production and business activities. The general theory of composition and decomposition of the system. Interfaces for transfer of product data. Virtual model of production-business systems. Digital enterprise. Integration of conventional and intelligent components. Unique resource of information. Information connection with business partners. Subsystems of integrated enterprise. Electronic archiving of information. Integrated quality assurance system. Communication network, protocols and services. Methodology of introduction of integrated systems and technologies.

practical teaching

Calculation of entropy in information and communication system. Neutral description of the product information for the entire life cycle. Information modeling of company. Functional modeling of company. Methodology analysis and synthesis of subsystems and modules. Description of business of company. Databases/knowledgebase. Design of output reports and business decision making. System of data searching. Information connection with business partners. Model of the company for training in the university's distance education with synergy between university and industry.

prerequisite

Defined in the curriculum of study program/module.

learning resources

Spasić, Ž., Integrated system of quality of digital university, MF, 2007.

Spasić, Ž., Computer Integrated Systems and Technologies, Textbook (in preparation).
Spasić, Ž. et al., Faculty of Mechanical Engineering, University of Belgrade - The mission of the path to European integration, MF, 2003.
Milačić, V., Spasić, Ž., Computer integrated manufacturing systems; MF, 1990.
Spasić, Ž. et al., Information integration of enterprise - CIM integration of management and quality, MF, 1994.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 0
laboratory exercises: 8
calculation tasks: 4
seminar works: 6
project design: 10
consultations: 2
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 1
check and assessment of lab reports: 1
check and assessment of seminar works: 2
check and assessment of projects: 2
colloquium, with assessment: 2
test, with assessment: 2
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 15
laboratory exercises: 10
calculation tasks: 10
seminar works: 10
project design: 10
final exam: 40
requirements to take the exam (number of points): 37

references

Computer Simulation in Manufacturing Automation

ID: MSc-0327
teaching professor: Пилиповић Д. Мирослав
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: production engineering

goals

The aim of the course is to acquaint the student with the application, design and introduction of modern manufacturing automation, with the use of computer simulation, to develop student skills for practical problem solving in automation, with the use of computer simulation, and to develop student proficiency in scientific methods of modeling computer simulation in manufacturing automation using modern simulation software.

learning outcomes

The student should understand the principles of computer simulation application in manufacturing automation, approach critically the effects of computer simulation application in automation, link knowledge from related subjects so as to apply it to computer simulation in automation, be proficient in scientific methods and theory of computer simulation for the manufacturing automation systems, be able of problem-solving in a critical manner and of applying contemporary software in automation simulation.

theoretical teaching

1.Computer simulation in automation. Continuous and discrete models. Deterministic and stochastic simulation.
2. Stochastic simulation. Sampling methods and random numbers. Monte Carlo simulation.
3. Discrete events simulation. Elements, object and operations in simulation. Activities cycle diagram. Simulation model building.
4. Software for discrete events simulation. Programming languages and simulation model programming.
5. Discrete events simulation project and simulation experiment.
6. Simulations in automation. Simulation models of fixed, programmable and flexible automation.
7. Continuous systems simulation. Formal model of continuous systems. Continuous systems with feedback.
8. Virtual manufacturing and simulation. Virtual manufacturing systems.

practical teaching

1.Auditorial exercises: tasks in stochastic simulation and Monte Carlo simulation, discrete events simulation, continuous systems simulation, and examples of simulation application in flexible and programmable automation.
2. Laboratory exercises.
3. Project: design of the example of automation with simulation model building, creation of the activities cycle diagram, creation of graphic models for simulation objects, design of simulation output: by programming, simulation experiment, results presentation and simulation model revision.

prerequisite

Defined by curriculum of study programm.

learning resources

1.Pilipović, M., Jakovljević, Ž., Computer simulation in manufacturing automation - Handouts, FME, Belgrade, 2011, DVL. /In Serbian/
2. Carrie, A. Simulations of manufacturing systems, John Willey & Sons, New York, 1988, KDA.
3. Computers for simulation programming, Lab for manufacturing automation, IKT/RRS. 4. Software for discrete events and continues systems simulation, Lab for manufacturing automation, IKT/RRO.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 8
laboratory exercises: 10
calculation tasks: 0
seminar works: 0
project design: 10
consultations: 2
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 4
check and assessment of seminar works: 0
check and assessment of projects: 2
colloquium, with assessment: 0
test, with assessment: 4
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 20
laboratory exercises: 15
calculation tasks: 0
seminar works: 0
project design: 20
final exam: 40
requirements to take the exam (number of points): 36

references

Pegden, D., Shannon, R., Sadowski, R., Introduction to Simulation Using Siman, McGRAW-HILL, 1995.
Kelton, W., Sadowski, R., Sadowski, D., Simulation with Arena, McGRAW-HILL, 1997.

Computer Simulation in Manufacturing Automation

ID: MSc-0722
teaching professor: Јаковљевић Б. Живана
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: production engineering

goals

The objective of this course is that students: acquire knowledge and skills needed for practical problems solving in manufacturing automation using computer simulation; to master the methods used for computer simulation modeling and implementation in manufacturing automation; to obtain the knowledge regarding the systematic approach to the project of computer simulation in manufacturing automation; to develop critical approach to the effects of computer simulation application in automation; to get familiar with the role of computer simulation within digital factory

learning outcomes

During this course students: master contemporary methods for development of conceptual models for continuous and discrete event simulation within the manufacturing automation framework; obtain knowledge and skills needed for model coding; gain practical experiences in creation of computer simulation in manufacturing automation through generation of computer models for continuous, discrete event and combined discrete event/continuous simulation using contemporary software; master the methodology of computer simulation project management

theoretical teaching

1. Introduction to computer simulation: simulation objectives; advantages and disadvantages of simulation; phases of computer simulation development; computer simulation in manufacturing automation; a variety of simulation models: continuous and discrete models, deterministic and stochastic simulation
2. Stochastic simulation: sampling methods, random numbers, random number generators, Monte Carlo simulation
3. Discrete event simulation: elements of discrete event simulation, conceptual modeling of discrete event simulation, activity cycle diagram
4. Computer models for discrete event simulation: approaches in model coding: activity based approach, event based approach, process based approach, the three phase approach; comparative analysis of different approaches
5. Discrete event simulation software: general purpose programming languages, application oriented simulation software; definition of simulation model in programming languages and simulation software packages; simulation outputs and results presentation; application of computer graphics and animation in simulation; application examples of simulation software
6. Discrete event simulation application in automation: generation of conceptual and computer models of fixed, programmable and flexible automation
7. Discrete event simulation project: system definition, generation of simulation model, model verification and validation, simulation experiments, results presentation and documentation
8. Continuous system simulation: continuous systems modeling, basic principles of numerical integration, modeling of the examples of continuous systems in manufacturing automation, programming languages and software for continuous system simulation, integration of continuous simulation into discrete event simulation
9. Digital factory and simulation: concept and models of digital factory; the role of simulation in digital factory: plant design and optimization, operational management and optimization

practical teaching

Laboratory exercises:
1. Monte Carlo simulation
2. Discrete event simulation software: ARENA – basic functioning principles and simulation examples
3. Discrete event modeling and simulation: examples of fixed and flexible automation
4. Continuous systems simulation: modeling and simulation of specific examples in the area of manufacturing automation using general purpose programming language and in application oriented simulation software – ARENA

Discrete event simulation project:
Students work on project dealing with the development of a simulation of a chosen flexible manufacturing system. During project realization students systematically implement all phases of discrete event simulation project: conceptual modeling, model coding, animation generation, model verification and validation, experimentation, analysis of the simulation results. The output is the report and project presentation at the end of semester

prerequisite

learning resources

Jakovljevic, Z., Computer simulation in manufacturing automation – lecture handouts
Computer classroom – each student individually works on a computer
Arena Simulation Software by Rockwell Automation
General purpose programming language

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 2
laboratory exercises: 12
calculation tasks: 0
seminar works: 0
project design: 16
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 1
check and assessment of seminar works: 0
check and assessment of projects: 1
colloquium, with assessment: 0
test, with assessment: 8
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 30
laboratory exercises: 10
calculation tasks: 0
seminar works: 0
project design: 20
final exam: 30
requirements to take the exam (number of points): 30

references

Carrie, A., Simulation of Manufacturing Systems, John Willey and Sons, New York, 1988
Robinson, S., Simulation: The Practice of Model Development and Use, John Willey and Sons, New York, 2004
Pidd, M., Computer Simulation in Management Science, John Willey and Sons, New York, 2004
Kelton, D., V., et al., Simulation with Arena, McGraw-Hill, 2009
Cellier, F., E., Kofman, E., Continuous System Simulation, Springer, New York, 2006

Coordinate Measuring Machines

ID: MSc-0240
teaching professor: Мајсторовић Д. Видосав
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: production engineering

goals

1.New knowledge of flexible metrological automation for solving ALL metrological problems in ENGINEERING, especially in production engineering.
2. Students should be equipped with new knowledge and skills relevant to:
- basic concepts, development and application of NCMM in engineering practice for measuring, control and inspection of all types of tolerances,
- research in the domain of NCMM (CMM),
- further development of NCMM (CMM).

learning outcomes

Having successfully acquired the teaching contents of this course, the student should be able to understand and solve metrological problems and apply the NCMM (CMM) to technological systems. He should be able to efficiently understand engineering metrological problems and solve them by using the concept of flexible metrological automation.

theoretical teaching

1.Development of the FA concept in PM. Generations in the NCMM development. Basic characteristics. Application. Software development for NCMM.
2. Detailed analysis of the fifth NCMM generation.
3. NCMM software support. General purpose software. Specific purpose software. Characteristics and application. Software development for NCMM. Integration.
4. NCMM programming. Off/on-line programming. Metrological model of a single part. Metrological primitives.
5. NCMM accuracy parameters. Testing the NCMM accuracy. Standards for NCMM testing. 6. NCMM integration into technological structures. FMM, FMC, FMS. NCMM (CMM) characteristics and function. Derived solutions.
7. Selected examples of NCMM application in industry. NCMM choice and effects of its application. Costs of NCMM application.
8. CAI model. Product metrological model. Expert systems for inspection planning on NCMM (CMM).
9. Research activities in NCMM (CMM). Virtual NCMM (CMM). Intelligent NCMM (CMM).

practical teaching

1.Ten laboratory exercises. NCMM (CMM) – basic structure and coordinate systems; determination of the angular measuring coordinate system /measuring, control and inspection; defining of geometrical and metrological primitive; NCMM (CMM) programming; inspection of length tolerance/; inspection of position tolerance; inspection of shape tolerance; gear inspection; camshaft and curve inspection; curved surface inspection.
2. NCMM (CMM) in practice – discussions and workshops. Analysis and synthesis of technical-technological documentation with respect to defining the metrological tasks for NCMM (CMM).

prerequisite

Compulsory: Obligatory courses of BSc academic studies.
Desirable: Elective courses of BSc academic studies.

learning resources

1. Handouts for each lecture /In Serbian/.
2. Instructions for lab exercises /In Serbian/.
3. Coordinate measuring machines (Textbook in preparation) /In Serbian/.
4. Web site for this course contains materials for 1. and 2. and a list of references as well as links to relevant web sites.
5. Technical equipment – lab for manufacturing metrology and TQM that has adequate equipment and licensed software.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 30
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 4
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 6
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 30
laboratory exercises: 20
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 40
requirements to take the exam (number of points): 36

references

Handouts for each lecture /In Serbian/.
Instructions for lab exercises /In Serbian/.
Coordinate measuring machines (Textbook in preparation) /In Serbian/.
Web site for this course contains materials for 1. and 2. and a list of references as well as links to relevant web sites.
Technical equipment – lab for manufacturing metrology and TQM that has adequate equipment and licensed software.

Decision-making methods

ID: MSc-0302
teaching professor: Миљковић Ђ. Зоран
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: project design
parent department: production engineering

goals

The aim of the course is to train the students to make decisions in the process of product development and design by using mathematical-algorithm procedures and artificial intelligence techniques. Development of students' creative abilities in improving technical/technological characteristics of a product using methods based on conceptual design points out the optimum decision function based on intelligent agents.

learning outcomes

The complex use of IT technologies in decision-making. The implementation of developed software in solving typical technological problems within decision-making methods based on artificial intelligence paradigms. Autonomous selection of the methods based on application of artificial neural networks in seeking the optimal solution in the process of product development. Capability for team work.

theoretical teaching

Introduction to the theory of decision-making; intelligent systems. Systems for design and selection of solutions. Hybrid intelligent manufacturing systems; decision-making methods based on intelligent agents. Decision-making based on artificial intelligence paradigms. Artificial neural networks; neuron - a processing element, transfer function (activation), architecture, learning algorithms. Application of artificial neural networks in decision-making. Manufacturability of the product, process planning optimization. Intelligent machines and decision-making. Development of advanced technologies for 21st century.

practical teaching

Conceptual design and decision-making variables (selected examples). Analysis of typical manufacturing problems in domain of decision-making (laboratory work). Algorithms of machine learning and knowledge-based presentation - decision tree. Software for simulation of artificial neural networks (laboratory work). Manufacturability of the product - design parameters based on material flow for chosen manufacturing process (selected examples). Machine learning of material flow for chosen manufacturing process. Intelligent machines and decision-making - mobile robots and machine learning (laboratory work). Examples of conceptual designed products with optimal performances, pointing out the application of advanced production technologies (project activities). Project design (design parameters, searching performances, and defining of a decision matrix and decision function).

prerequisite

Defined by Curriculum.

learning resources

[1] Z. Miljković, D. Aleksendrić, ARTIFICIAL NEURAL NETWORKS – solved examples with

short theory background, Textbook, University of Belgrade, Faculty of Mechanical Engineering, 2009, 18.1 /In Serbian/
[2] Z. Miljković, SYSTEMS OF ARTIFICIAL NEURAL NETWORKS IN PRODUCTION TECHNOLOGIES, Series IMS, Vol. 8, University of Belgrade, Faculty of Mechanical Engineering, 2003, 18.1 /In Serbian/
[3] V.R. Milačić, MANUFACTURING SYSTEMS DESIGN THEORY, Series IMS, Vol. 2, University of Belgrade, Faculty of Mechanical Engineering, 1987, 18.1 /In Serbian/
[4] Z. Miljković, Handouts, University of Belgrade, Faculty of Mechanical Engineering, 2012, 18.1 /In Serbian/
[5] Z. Miljković, Software "Moodle" for distance learning (http://147.91.26.15/moodle/), University of Belgrade, Faculty of Mechanical Engineering, 2012, 18.13
[6] Z. Miljković, Website for Decision-making methods (http://cent.mas.bg.ac.rs/), University of Belgrade, Faculty of Mechanical Engineering, 2012, 18.13
[7] Z. Miljković, Software packages for simulation of artificial neural networks - BPnet, ART Simulator, Matlab; Laboratory CeNT website: http://cent.mas.bg.ac.rs/, University of Belgrade, Faculty of Mechanical Engineering, 18.13
[8] Laboratory mobile robot prototype (Khepera II, LEGO Mindstorm NXT), Laboratory CeNT, University of Belgrade, Faculty of Mechanical Engineering, 18.12
[9] Laboratory model of designed manufacturing system, Laboratory CeNT, University of Belgrade, Faculty of Mechanical Engineering, 18.12

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 0
laboratory exercises: 16
calculation tasks: 0
seminar works: 0
project design: 9
consultations: 5
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 3
colloquium, with assessment: 3
test, with assessment: 4
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 25
laboratory exercises: 0

calculation tasks: 0
seminar works: 0
project design: 35
final exam: 30
requirements to take the exam (number of points): 30

references

Y. Hatamura, (2006) DECISION-MAKING IN ENGINEERING DESIGN, Springer-Verlag London Limited, Printed in Germany.
J. N. Siddall, (1972) ANALYTICAL DECISION-MAKING IN ENGINEERING DESIGN, Prentice-Hall, Inc. Englewood Cliffs, New Jersey.
N. P. Suh, (1990) THE PRINCIPLES OF DESIGN, Oxford University Press, New York.
E. Alpaydin, (2004) INTRODUCTION TO MACHINE LEARNING, The MIT Press, Cambridge, Massachusetts London, England.
R. R. Murphy, (2000) INTRODUCTION TO AI ROBOTICS, A Bradford Book, The MIT Press, Cambridge, Massachusetts London, England.

Expert Systems

ID: MSc-0217
teaching professor: Мајсторовић Д. Видосав
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: production engineering

goals

1.Acquisition of new knowledge about the new generations of software products for solving various engineering problems relevant to production engineering.
2. Acquisition of knowledge and development of skills relevant to:
- basic concepts, development and models of expert systems which are possible to apply in production engineering,
- investigations in the ES area,
- further development of ES.

learning outcomes

The student should be able to understand, solve and develop models by means of ES in technological systems. The student should also be able to effectively understand engineering problems and develop their models by using contemporary software tools.

theoretical teaching

Theoretical teaching comprises 10 teaching units:
1. The development of artificial intelligence (AI) concept. The expert system (ES) concept. The role and place of ES in AI.
2. Engineering problems (design, planning, control) and their modeling using ES.
3. Generations of ES development. Basic ES structure. Stages of ES design and development.
4. Knowledge and types of knowledge. Models of knowledge base. Large knowledge bases.
5. Examples of knowledge presentation in ES.
6. Models of reasoning lines. Models of conclusion-making. Models of ES user's interface.
7. Shell Es. Programming and programming languages for ES. Learning and learning models.
8. Selected examples of ES application in engineering. ES for maintenance program (EXMAS).
9. ES for inspection program on NCMM (CMM) (EXINS).
10. Intelligent business systems. Future development of ES.

practical teaching

Practical teaching covers:
1. ES project for a concrete engineering problem. The project will be accomplished through the following stages: Engineering problem analysis and modeling for ES; development and testing of knowledge base; development and testing of reasoning line and conclusion-making model; experimental model testing.
2. ES in practice – discussions and workshops. This part of exercises focuses on student own deduction on how to approach the engineering ES application. This will be realized through the analysis and synthesis of ES application cases to solving various engineering problems.

prerequisite

Compulsory: Courses of BSc studies at FME or other Technical Faculties.
Desirable: Elective courses of BSc academic studies.

learning resources

1. Handouts for each teaching unit /In Serbian/.
2. Instructions for project design /In Serbian/.
3. Expert systems (Textbook in preparation) /In Serbian/.
4. Web site for this course contains materials for 1. and 2. and a list of references as well as links to relevant web sites.
5. Technical equipment – Lab for manufacturing metrology and TQM that has adequate equipment and licensed software.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 30
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 4
colloquium, with assessment: 0
test, with assessment: 6
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 30
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 20
final exam: 40
requirements to take the exam (number of points): 36

references

Handouts for each teaching unit /In Serbian/.
Instructions for project design /In Serbian/.
Expert systems (Textbook in preparation) /In Serbian/.
Web site for this course contains materials for 1. and 2. and a list of references as well as links to relevant web sites.
Technical equipment – Lab for manufacturing metrology and TQM that has adequate equipment and licensed software.

Industrial robots

ID: MSc-0290
teaching professor: Милутиновић С. Драган
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: production engineering

goals

The student should acquire fundamental knowledge of industrial robots (basic subsystems, their functioning variants and realization), knowledge needed for robot design, robotized workplaces design, robot programming, develop capability for further dealing with subject matter of the discipline.

learning outcomes

Fundamental knowledge of robots and current issues in their design, building and application. Knowledge needed for robot design. Capability to perceive the importance of robot application (effects on productivity, flexibility, product quality and humanization of work). Knowledge and skills for introducing of robots to the plant/factory. Practical experience in robot programming.

theoretical teaching

New teaching contents: 1. Definitions, functional structure of a robot, with subsystem description, classification. 2. Robot kinematics: spatial descriptions and transformations, direct and inverse kinematics problem. 3. Robot control. Control system structure. Single axis control (drive and measuring system, transmission system). Types of control (PTP and CP). 4. Sensors, internal and external. End effectors, grippers, and tools. 5. Robot programming, methods. Robot programming languages. 6. Robot application. Robot cell layouts and cycle time analysis. Manipulation and process tasks, assembly, techno-economic analysis. Explanations of new teaching contents. 1. Robot mechanical structure – manipulator. 2. Description of orientation. Algorithm of associating coordinate systems to segments. The Jacobian. 3. Recognition systems.

practical teaching

Practical teaching: Five auditorial exercises: Kinematics of manipulators. Analysis of drive systems, measuring systems, transmission systems. End effectors. Robot programming. Robot application. 2. Four calculation tasks: Spatial relations and transformations. Robot kinematics and cycle time analysis. Distribution of three calculation tasks relates to all these areas. 3. Three laboratory exercises: Robot kinematic (mechanical) structure – manipulator. Drive systems, measuring systems, transmission systems. Robot programming. 4. Seminar work: robot kinematics, programming, cycle time analysis.

prerequisite

Study curriculum and student motivation for learning industrial robots according to the goals set and outcomes offered.

learning resources

1. Textbook: Industrial robots by D. Milutinović (in preparation)/In Serbian/
2. Handouts for each lecture /In Serbian/

3. Instructions for doing tasks, lab exercises and seminar work /In Serbian/
4. The Course site (http://cent.mas.bg.ac.rs/nastava/ir_msc/index.htm) containing references and addresses of robot manufacturers and respective institutions (IFR, RIA, JARA, CIRP...).
5. Craig J.J. (1989) Introduction to Robotics: Mechanics and Control, Addison Wesley.
6. Sciavicco L., Siciliano B., (2005) Modelling and Control of Robot Manipulators, Springer.
7. Facility: Laboratory for industrial robotics and artificial intelligence, with 4 industrial robots, robot languages PASRO and software for simulation and programming WORKSPACE 5 and teaching aids.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 13
laboratory exercises: 8
calculation tasks: 8
seminar works: 1
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 3
check and assessment of lab reports: 0
check and assessment of seminar works: 1
check and assessment of projects: 0
colloquium, with assessment: 2
test, with assessment: 4
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 60
laboratory exercises: 0
calculation tasks: 0
seminar works: 10
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

Niku S.B. (2001) Introduction to Robotics: Analysis, Systems, Applications, Prentice Hall.
Fu K.S., Gonzales R.C., Lee C.S.G. (1987) Robotics: Control, Sensing, Vision, and Intelligence, McGraw-Hill, New York.
Groover P.M., Weiss M., Nagel R.N., Odrey N.G. (1986) Industrial Robotics: Technology, Programming and Applications, McGraw-Hill, New York.
Tsai L.-W. (1999) Robot Analysis: The Mechanics of Serial and Parallel Manipulators, Wiley, New York.
Pires M.J. (2007) Industrial Robot Programming, Springer.

Intelligent manufacturing systems

ID: MSc-0131
teaching professor: Миљковић Ђ. Зоран
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: project design
parent department: production engineering

goals

The aims of the course are to develop student ability for conceptual design and implementation of intelligent manufacturing systems and processes by using the design theory, machine learning and evolutiveness, based on artificial intelligence paradigms. After he/she becomes familiar with the structure of intelligent manufacturing system based on intelligent agents (robot, machine tool, machine learning, software, etc.) using laboratory equipment like mobile robots, as well as simulation using specialized software, the student will acquire knowledge necessary for the development of advanced production technologies.

learning outcomes

Implementation of software developed for modeling and analysis of intelligent manufacturing systems and processes. Independent selection of methods based on the application of artificial neural networks in domain of conceptual design of intelligent behaviour of autonomous mobile robots in manufacturing environment. Advanced use of the software for simulation, with analysis and presentation of the results obtained. Capability for team work.

theoretical teaching

Introduction to knowledge and machine learning-based intelligent systems. Machine learning model; deduction, induction and analogy. Machine learning as a basis of intelligent systems and processes. Evolutiveness and intelligent systems. Autonomy, basic concepts and importance. Autonomous mobile robots. Mobile robot localization and interactions with objects in a manufacturing environment. The design theory of manufacturing systems. Software tools for conceptual manufacturing systems design. Conceptual design of manufacturing system layout. Examples of developed systems.

practical teaching

Modeling and analysis of intelligent manufacturing systems and processes (laboratory work). Examplified application of developed intelligent systems (laboratory work). Software for simulation of artificial neural networks (laboratory work). Software architectures for machine learning of intelligent systems. Intelligent behaviour based on empirical control algorithm. Subsumption architecture of intelligent systems based on level of competence (intelligent behaviour design of autonomous mobile robot). Software for conceptual design of manufacturing system layout. Project design (Material handling; Intelligent control of autonomous mobile robot).

prerequisite

Defined by Curriculum.

learning resources

[1] Z. Miljković, D. Aleksendrić, ARTIFICIAL NEURAL NETWORKS – solved examples with

short theory background, Textbook, University of Belgrade, Faculty of Mechanical Engineering, 2009, 18.1 /In Serbian/
[2] M. Kalajdžić (editor), Lj. Tanović, B. Babić, M. Glavonjić, Z. Miljković, et al., CUTTING TECHNOLOGY (6th ed.), Handbook, University of Belgrade, Faculty of Mechanical Engineering, 2008, 18.1 /In Serbian/
[3] Z. Miljković, Systems of artificial neural networks in production technologies, Series IMS, Vol. 8, University of Belgrade, Faculty of Mechanical Engineering, 2003, 18.1 /In Serbian/
[4] Z. Miljković, Handouts, University of Belgrade, Faculty of Mechanical Engineering, 2012, 18.1 /In Serbian/
[5] Z. Miljković, Software "Moodle" for distance learning (http://147.91.26.15/moodle/), University of Belgrade, Faculty of Mechanical Engineering, 2012, 18.13
[6] Z. Miljković, Website for IMS (http://cent.mas.bg.ac.rs/), University of Belgrade, Faculty of Mechanical Engineering, 2012, 18.13
[7] B. Babić, FLEXY - Intelligent system for FMS design, Series IMS, Vol. 5, University of Belgrade, Faculty of Mechanical Engineering, 1994, 18.1 /In Serbian/
[8] Laboratory mobile robot prototype (Khepera II, LEGO Mindstorm NXT), Laboratory CeNT, University of Belgrade, Faculty of Mechanical Engineering, 18.12
[9] Laboratory model of designed manufacturing system, Laboratory CeNT, University of Belgrade, Faculty of Mechanical Engineering, 18.12
[10] Software packages (BPnet, ART Simulator, Matlab, AnyLogic, Flexy), Laboratory CeNT, University of Belgrade, Faculty of Mechanical Engineering, 18.13

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 0
laboratory exercises: 15
calculation tasks: 0
seminar works: 0
project design: 15
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 4
colloquium, with assessment: 2
test, with assessment: 4
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 15
test/colloquium: 20

laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 35
final exam: 30
requirements to take the exam (number of points): 30

references

R.Siegwart,I.R.Nourbakhsh, INTRODUCTION TO AUTONOMOUS MOBILE ROBOTS, The MIT Press, 2004.
J.Banks,J.S.Carson,B.L.Nelson,D.M.Nicol, DISCRETE EVENT SYSTEM SIMULATION, 4th Ed., Pearson Education International Series, 2005.
N.P.Suh, THE PRINCIPLES OF DESIGN, Oxford University Press, 1990.
E.Alpaydin, INTRODUCTION TO MACHINE LEARNING, The MIT Press, 2004.
R.R.Murphy, INTRODUCTION TO AI ROBOTICS, The MIT Press, 2000.

Machine tools M

ID: MSc-0476
teaching professor: Главоњић М. Милош
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: production engineering

goals

1. To develop ability to perceive typical missions of machining systems.
2. To study machine tools mechanisms and systems for their control and programming. 3. To receive training in testing procedures for machine tools.
4. To develop ability to analyze complex machine tools and machining systems equipment.
5. The develop ability to analyze the resources for machine tools development.
6. To study configuring and/or building of machine tools for planned mission.
7. To receive training for realization of one mission of machine tools through writing the seminar work.
8. To know how to make technical projects.

learning outcomes

1. Knowledge about typical missions of machining systems.
2. Basic knowledge about machine tools mechanisms and control and programming systems of new generation.
3. Skill for quality evaluation of machine tools and machining system based on results of performed testing.
4. Skill for identifying the generation of machine tool and machining system.
5. Skill for configuring machine tool for one's own needs.
6. Knowledge about available resources for development and/or upgrading of machine tools and machining systems.

theoretical teaching

New teaching contents:
1. AH-1 Consolidation of the curriculum for Machine Tools M.
2. AN-2 Machine tools mechanisms.
3. AN-3 Configuring machine tools.
4. AN-4 Open-architecture machine tools control.
5. AN-5 Object programming of machine tools.
6. AN-6 Testing of machine tools and machining systems.
7. AN-7 Complex machine tools.
8. AN-8 Machine tools and machining systems equipment.
9. AN-9 Resources for machine tools and machining systems development.
Extension:
1. AR-1 Extension of the theme AN-2 using the examples of support structures, guides, leading spindle etc.
2. AR-2 Extension of the theme AN-3: Methods of configuring new machine tools.
3. AR-3 Extension of the theme AN-4: The EMC2 System for machine tools control.
4. AR-4 Extension of the theme AN-5: The STEP-NC Protocol for programming machine tools.
5. AR-5 Extension of the theme AN-6: Examples of complete procedures for testing machine tools.

practical teaching

1.Auditorial exercises:
(1)Resources for studying machine tolls. (2)Plan and program of laboratory exercises.
2. Laboratory exercises:
(1)Machining system static stiffness. (2)Testing lathe accuracy. (3)Working accuracy of numerically-controlled milling machines. (4)Circular interpolation test, or, One combined testing of machining system.
3. Seminar work.

prerequisite

Study curriculum and student motivation for learning about machine tools and machining systems according to the goals set and outcomes offered.

learning resources

1. N.N, Visionary Manufacturing Challenges for 2020, National Academy Press, Washington, D.C. 1998, ISBN 0-309-06182-2.
2. W. R. Moore, Foundations of Mechanical Accuracy, The Moore Special Tool Company, First Edition, Third Printing, 1999.
3. X. Xu, A.Y.C. Nee, Advanced Design and Manufacturing Based on STEP, Springer, 2009, ISBN 978-1-84882-738-7.
4. D. Zhang, Parallel Robotic Machine Tools, Springer, 2010, ISBN 978-1-4419-1116-2.
5. W. A. Khan, A. Raouf, K. Cheng, Virtual Manufacturing, Springer, 2011, ISBN 978-0-85729-185-1.
6. H. A. ElMaraghy (Ed), Changeable and Reconfigurable Manufacturing Systems, Springer, 2009, ISBN: 978-1-84882-066-1.
7. K. Apro, Secrets ot 5-Axis Machining, Industrial Press, 2008, ISBN 978-0-8311-3375.
8. M. Weck, C. Brecher, Werkzeugmaschinen 1, Maschinenarten und Anwendungsbereiche, Springer, 2005, ISBN 10 3-540-22504-8.
9. M. Weck, C. Brecher, Werkzeugmaschinen 2, Konstruktion und Berechnung, Springer 2006, ISBN 10 3-540-22502-1.
10. R. Neugebauer (Hrsg.), Parallelkinematische Maschinen Entwurf, Konstruktion, Anwendung, Springer, 2006, ISBN 10 3-540-20991-3.
11. LPI-1: Three work places with manually controlled machine tools.
12. LPI-2: Three work places with numerically controlled machine tools.
13. LMS-1: The system for circular interpolation test.
14. LMS-2: The system for laboratory testing of machine tools accuracy.
15. LRS-1: One developmental work place with machine tool of the MOMA type.
16. LRS-2: One work place for testing machine tools mechanisms.
17. LPS-1: Work places for programming machine tool of the MOMA type.
18. APS-1: The system for experimental data acquisition and processing.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 3
laboratory exercises: 17
calculation tasks: 0

seminar works: 10
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 3
test, with assessment: 7
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 35
laboratory exercises: 15
calculation tasks: 0
seminar works: 20
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

F. Kimura, K. Horio (Eds.), Towards Synthesis of Micro-/Nano-systems, Springer, 2006, ISBN13: 9781846285585.
M. Mitsuishi, K. Ueda, F. Kimura (Eds.), Manufacturing Systems and Technologies for the New Frontier, Springer, 2008, ISBN 978-1-84800-266-1.
M. Weck, C. Brecher, Werkzeugmaschinen 3, Mechatronische Systeme, Vorschubantriebe, Prozessdiagnose, Springer, 2006, ISBN 10 3-540-22506-4.
M. Weck, C. Brecher, Werkzeugmaschinen 4, Automatisierung von Maschinen und Anlagen, Springer, 2006, ISBN 10 3-540-22507-2.
M. Weck, C. Brecher, Werkzeugmaschinen 5, Messtechnische Untersuchung und Beurteilung, dynamische Stabilität, Springer, 2006, ISBN 10 3-540-22505-6.

Manufacturing Automation

ID: MSc-0268
teaching professor: Пилиповић Д. Мирослав
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: production engineering

goals

The student should acquire knowledge of the application, design and introduction of modern manufacturing automation, master the skills of practical problem-solving in the domain of automation by using computerized, information, control, manufacturing and other technologies and appropriate scientific methods.

learning outcomes

The student should understand the principles of modern manufacturing automation, develop critical approach to social, economic, manufacturing and other effects generated by introducing automation to manufacturing process, combines knowledge of related subjects in order to apply it in automation, master scientific methods of analysis, synthesis, design and introduction of manufacturing automation system, develop capability to use computerized technologies and modern control systems in manufacturing automation.

theoretical teaching

1.The role of automation in manufacturing. Objectives, strategy, factors and types of automation. Fixed, programmable, flexible automation, unmanned factory.
2. Informatics in automation. Switching algebra. Logical functions, theorems and normal forms.
3. Automation technologies and instruments. Control structure. Information, control and energy blocks. Sensors, actuators, logic and memory elements.
4. Combination and sequential automata. Definitions, models, analysis and synthesis. Pneumatic and electro-pneumatic realization of manufacturing automation.
5. Programmable controllers. Functions, hardware, software, input-output modules. Programming languages and programming.
6. Examples of modern manufacturing automation.

practical teaching

1.Auditorial exercises: Tasks in exemplified automation design, with control system analysis and synthesis, programmable controllers programming and control scheme design.
2. Laboratory exercises: exemplified automation design, with control system analysis and synthesis and practical realization of the example in laboratory conditions by applying pneumatic, electro-pneumatic, electrical and electronic components, modular robots and control systems based on computer and programmable controllers with programming.
3. Seminar work: exemplified automation design, with control system synthesis, programmable controllers programming and control scheme design.

prerequisite

Defined by curriculum of study program.

learning resources

1.Svetislav Z., Manufacturing automation, FME, Belgrade, 1990, KDA. /In Serbian/
2. Pilipović M., Manufacting processes automation: Laboratory, FME, Belgrade, 2006, PRA. /In Serbian/
3. Pilipovic, M., Manufacturing automation - Handouts, FME, Belgrade, 2011, DVL. /In Serbian/
4. Lab desk with pneumatic, electro-pneumatic and electric components and programmable controllers, Lab for manufacturing automation, EOP/LRS.
5. "Pick and Place" electro-pneumatic modular robots with programmable controllers, Lab for manufacturing automation, EOP/LPI.
6. Programming computers, Lab for manufacturing automation, IKT/PPC.
7. Software for programmable controller programming, Lab for manufacturing automation, IKT/RRO.
8. Communication network of computers and programmable controllers, Lab for manufacturing automation, IKT/KIO.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 10
laboratory exercises: 12
calculation tasks: 0
seminar works: 6
project design: 0
consultations: 2
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 4
check and assessment of seminar works: 2
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 4
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 20
laboratory exercises: 20
calculation tasks: 0
seminar works: 15
project design: 0
final exam: 40
requirements to take the exam (number of points): 36

references

Groover, M., Automation, Production Systems and Computer Integrated Manufacturing, Prentice-Hall, Inc. 1987.
Informatika, Info 73 Programmable Controllers - Programming Guide, Informatika, 2010. /In Serbian/
Informatika, Info 73 Programmable Controllers - Installation Guide, Informatika 2010. /In Serbian/
Pessen, D., Industrial Automation - Circuit Design and Components, Willey & Sons, 1989.

Manufacturing Systems Design

ID: MSc-0177
teaching professor: Петровић Б. Петар
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: production engineering

goals

1. Understanding of modern manufacturing systems structure – a survey of main subsystems and their mutual interaction;
2. Static and dynamic properties of the manufacturing system, dynamic nature of cutting process, nonlinear phenomena of friction, chatter and other aspects affecting manufacturing system stability;
3. Fundamental knowledge of numerically controlled axes, Computer Numerical Control, control system architecture, human-machine interfacing, and manufacturing system condition monitoring;
4. Fundamental approaches to manufacturing systems design theory (Axiomatic design, TRIZ and other alternative approaches).

learning outcomes

1. The student should be able to design, i.e., conceptualize, analyze and synthesize manufacturing system in accordance to given functional requirements.
2. The student should develop knowledge, skills and practice for using broad range of CAx modeling methods, including FEM, needed for manufacturing system design and optimization.
3. The student should understand structure of Computer Numerical Control system, its basic architecture and subsystems, and how to specify and/or configure it properly.

theoretical teaching

Theoretical teaching embraces three basic teaching units:
1. Structure and configuration of the manufacturing system – generic structure of the manufacturing system; morphology, static and dynamic aspects of the machine-tool-workpiece interaction, basics of modal analysis; cutting process dynamics, and stability aspects.
2. Control system – basics of numerically controlled machine tool: servo axis, fundamental principles of servoregulation; interpolation and motion control, architecture and configuration of CNC control systems;
3. Manufacturing systems design – introduction to the theory of axiomatic design, design axioms and corollaries; functional requirements and constraints, design matrix and forms of coupling, complexity - structuring and decomposing designs, domain of technology and processes; Theory of Inventive Problem Solving (TRIZ).

practical teaching

Laboratory exercises are organized within the framework of three exercises: 1. manufacturing system statics, 2. manufacturing system dynamics and modal analysis techniques, and 3. control system NUMA (servo axis, engagement of servo axes and contour control, configuring a manufacturing system). Project: project of an assigned manufacturing system or any of its subsystems, focus being on multidisciplinary (mechatronics) approach in solving the problem posed. Students are oriented to using the Internet, contemporary CAD techniques in the design process, team work and practical verification in the laboratory.

prerequisite

Basic knowledge in Mechanics, Machine Tools, Tools, Jigs and Fixtures, Numerical methods and CAD, Electronics, Control Systems, Cybernetics.

learning resources

[1] P.B. Petrovich, Manufacturing systems design /In Serbian/,
[2] Designer Atlas of Machine Tools,
[3] Handouts in e-form /In Serbian/,
[4] Instructions for laboratory report writing /In Serbian/,
[5] Instructions and prominent example of the Manufacturing System Design project /In Serbian/.
[6] Manufacturing systems in Machine workshop of the Department for Production Engineering: 1)Conventional machines - lathes, milling machines and grinding machines, 2) Numerically controlled machines - CNC Lathe and Horizontal machining center with 4 dof.,
[7] Sensory and digital acquisition system for modal analysis of manufacturing systems,
[8] Components of numerically controlled servo axes,
[9] Open architecture CNC control system for motion control of servo driven axes in modern machine tools,
[10] CAD development tools for identification and simulation of static and dynamical behavior of manufacturing systems.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 6
laboratory exercises: 6
calculation tasks: 0
seminar works: 0
project design: 16
consultations: 2
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 2
check and assessment of seminar works: 0
check and assessment of projects: 2
colloquium, with assessment: 0
test, with assessment: 6
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 25

laboratory exercises: 10
calculation tasks: 0
seminar works: 0
project design: 15
final exam: 40
requirements to take the exam (number of points): 30

references

Suk-Hwan Suh, at all, Theory and Design of CNC Systems, 2008 Springer-Verlag London Limited, ISBN 978-1-84800-335-4

Mechatronics systems

ID: MSc-0342
teaching professor: Петровић Б. Петар
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: production engineering

goals

The aim of the course in mechatronics systems is to provide a focused interdisciplinary theoretical knowledge and practical experience for undergraduate students that encompass fundamental elements from traditional courses in mechanical engineering, production engineering, electronics and computer control engineering. These elements include sensors and measurement theory, digital systems and computation, semiconductor electronics, servoactuators and motion control, machine tools and robotics, altogether focused in deeper understanding of mechatronics aspects of modern manufacturing systems design, i.e., design of CNC machine tools, industrial robots and flexible production lines, based on contemporary numerical and computer control technology.

learning outcomes

1. Theoretical and practical knowledge how to design and select analog and digital circuits, microprocessor-based components, mechanical devices, sensors and actuators, so that the manufacturing equipment, i.e., machine tools, manipulating robots and manufacturing lines achieve desired function.
2. Deep understanding of basic principles of computer based numerical control systems and their application in machine tools, manipulating robots and industrial automation systems design.
3. Microcontroller programming and hardware design skills.

theoretical teaching

Theoretical teaching is organized in four teaching units:
1. Importance and role of mechatronics in modern manufacturing systems design,
2. Digital systems, microprocessors and microcontrollers – basic digital modules, arithmetic logic unit, microprocessor, machine and assembly language, microcontroller architecture and programming,
3. Sensory systems, signal conditioning, measurements and signal processing – working principles and design of sensors for force, displacement and speed measurement, signal conditioning based on semiconductor electronics, fundamentals of digital signal processing, vision sensors and systems, and
4. Electrical servo drives and motion control – stepper and dc motor fundamentals, servo drivers and numerically controlled servo axis, motion control and interpolation, CNC system architecture .

practical teaching

Practical training is organized through laboratory exercises and project of mechatronics system design in the field of manufacturing technoloogy.
LAB 1: Microcontroller – demonstration of development system based on Microchip PIC16F87 microcontroller, hardware architecture, microcontroller programming in assembler language, application development using high-level programming languages (MicroPascal, MicroC), working with digital and analogue signals, digital interfaces and microcontroller networking;

LAB 2: Intelligent sensor systems in manufacturing – architecture of intelligent sensor system, design and operation of multi DOF force sensor based on strain gauge transducers, design and operation of laser triangulation sensor for highly accurate contactless displacement measurement, vision sensors and image analysis;
LAB 3: Servo drives and motion control – brushless dc servomotor, servo driver architecture and technical details, servo axis configuration and tuning, contour motion control - synchronization of two servo axes and demonstration of various kinds of interpolation algorithms, performances evaluation, demonstration of CNC system architecture and its building blocks.
Project: mechatronic system design using microcontrollers, microprocessor based sensory signal conditioning and processing, and servocontrolled actuators. The project is focused on specific problem closely related to real industrial scenarios.

prerequisite

Fundamental knowledge on Dynamics of mechanical systems, Electrical Engineering, Control Systems Eng., Cybernetics, and Computer programming skills

learning resources

[1] P.B.Petrović, Mechatronics systems in mechanical engineering (Textbook in preparation) /In Serbian/;
[2] Handouts for each lecture. /In Serbian/;
[3] Instructions for writing laboratory reports/In Serbian/,
[4] Instructions and a referent example of the project /In Serbian/,
[5] Instructions for safe handling of laboratory equipment /In Serbian/.
[6] MatLab simulation system practical training in dynamic systems simulation and analyis,
[7] Development system based on Microchip PIC16 and PIC18 RISC microcontrollers for practical understanding digital computer organization and machine language,
[8] Compilers and High-level language development systems for Microchip PIC16 and PIC18 RISC microcontrollers (MicroC, MicroPascal),
[9] Peripheral modules for Microchip PIC16 and PIC18 RISC microcontrollers for practical trainings with digital and analogue signals, interfacing and networking and building human-machine interfaces,
[10] Force sensing demonstration and training installation (multy dof. strain gauge based senors, signal conditioning and digital signal acquisition system),
[11] Noncontact displacement measuring 3d scanning system based on laser triangulation and structured light concepts; demonstration and training installation (sensory sistems, signal conditioning and digital signal acquisition system, digital signal processing and information extraction),
[12] Servo-axis demonstration and training test bead (servomotors, mechanical drive components, displacement measuring sensors (encoders), guiding system),
[13] Open architecture control system for motion control demonstration of servodriven systems, HMI and control code development system from CAD data
[14] Robot arms and mobile robot for students training in practical use of microcontrollers for different tasks in motion control of complex mechanical systems.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 6
laboratory exercises: 6
calculation tasks: 0
seminar works: 0
project design: 16
consultations: 2
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 1
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 3
test, with assessment: 6
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 25
laboratory exercises: 10
calculation tasks: 0
seminar works: 0
project design: 15
final exam: 40
requirements to take the exam (number of points): 30

references

W. Bolton, Mechatronics – Electronic control systems in mechanical and electrical engineering, Prentice Hall, 2003.
D. Alciatore, and M. Histand, Introduction to Mechatronics and Measurement Systems, McGraw-Hill Company, 2003.
Suk-Hwan Suh, at all, Theory and Design of CNC Systems, 2008 Springer-Verlag London Limited, ISBN 978-1-84800-335-4
Robert H. Bishop, MECHATRONICS - AN INTRODUCTION. Published in 2006 by CRC Press, Taylor & Francis Group, ISBN 0-8493-6358-6.

Micro Manufacturing and Characterization

ID: MSc-0601
teaching professor: Бојовић А. Божица
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: production engineering

goals

The course's goals are: students should achieve a basic knowledge of micro-machining technologies through study manufacturing and measuring systems and their functions in the micro scale, as well as the necessary knowledge for the manufacturing and characterization of parts of contemporary materials; students should study in details the chosen method; students will be trained to write term paper, elaborate on lessons learned and be able to continue practicing this discipline in the profession either further education or research in this area.

learning outcomes

Student understands the principles of micro-manufacturing, connecting knowledge from related items in order of their use in the manufacture of parts and characterization contemporary materials, mastery of scientific methods of analysis, synthesis and design, applied computer technology and develop a critical approach to social and economic effects of the introduction of micro-manufacturing in our economy. Skills and knowledge in this course will enable student participation in our economy, according to business requirements in the markets of developed countries.

theoretical teaching

AT-1: Introduction to micro technology and an overview of previous situation in that area; AT-2: Methods for micro-cutting process, AT-3: Methods of processing micro-plastic deformation; AT-4: Methods of processing micro-pressure casting polymer; AT-5 : Methods of processing micro electro erosive processing; AT-6: Micro Metrology, AT-7: Fundamentals microtribology and its role in micro technologies, AT-8: Characterization of engineering surfaces, AT-9: Application of laser in microtechnology, AT-10: Microlithography.

practical teaching

PA-1, PA-2 PA-3 PA-4 PA-5 PA-6: Examples of implemented solutions regarding the teaching topics, PZ-1: The task in the field of micro-processing, PZ-2: The task in the field of micro-metrology; PZ-3: The task in the field of characterization; PL-1, PL-2: Laboratory practice in the field of micro-cutting, PL-3: Laboratory practice in the field of micro-measurements, PK-1, PK-2: Consultation regarding the term paper , PS-1: Term paper title choosing and definition of the paper, PS-2: Searching the available literature; PS-3: Searching the Internet resources, PS-4: Analysis of collected information ; PS-5 PS-6 PS-7, PS- 8: Independent work on term paper , PS-9: Final work on the preparation of term paper, PS-10: Finalisation of the paper by making and preparing presentations;

prerequisite

Defined by the Study Program Curriculum

learning resources

Handouts - writing material in the form of pdf and ppt files from the lecture.
The scanning microscope JSPM-5200 and software for image processing WinSPM Ver.2.5, CNC lathe Politech Aspheric 1800 - Toric,
milling machine - Roland CAMM PNC2300-2.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 20

active teaching (practical)

auditory exercises: 12
laboratory exercises: 6
calculation tasks: 6
seminar works: 14
project design: 0
consultations: 2
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 1
check and assessment of lab reports: 1
check and assessment of seminar works: 4
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 4
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 20
laboratory exercises: 10
calculation tasks: 10
seminar works: 30
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

Ehman, K., Bourell, D., Culpepper, M., at al. MICROMANUFACTURING, Springer, Netherlands, 2007.
Lasagni, F., Lasagni, A., FABRICATION AND CHARACTERIZATION IN THE MICRO-NANO RANGE, Springer, Berlin, 2011.
Franssila, S. INTRODUCTION TO MICRO FABRICATION, John Wiley & Sons, Ltd. England, 2004.
Jackson, M. MICROFABRICATION AND NANOMANUFACTURING, Taylor & Francis Group, New York, 2006.
Mahalik, N.P. MICROMANUFACTURING AND NANOTECHNOLOGY, Springer, Germany, 2006

Micro-nano Engineering Basics

ID: MSc-0575
teaching professor: Бојовић А. Божица
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 4
final exam: oral
parent department: production engineering

goals

Mastering the basic principles prevailing in the micron and submicron region. Introduce students to theoretical foundations, principles and methods of manufacturing in the field of micro-and nano-engineering of various materials. Developing a different engineering approach realized through access to examples and work on their own ideas.

learning outcomes

After passing the examination the student is able to understand the principles and use different technologies for manufacturing micro and nano structures, devices and systems. The student is familiar with actual examples and encouraged towards the realization of their ideas.

theoretical teaching

Micro and nano manufacturing. Micromachining methods. Application of lasers in micro and nano region. Etching. Thin Film Deposition and Doping methods. Lithography methods. Epitaxy methods. Self-Assembly methods. Quantum Structure nanofabrication. Scanned Probe Techniques.

practical teaching

Examples of implemented micro or nano-manufacturing in industrial applications, with consumer goods, medical and electromechanical systems (M/NEMS). Contact lens diamond turnning and polishing. Examples of application of lasers in micro and nano manufacturing. Production of carbon nanotubes. Application of "lotus effect" and the generation of nanostructures. Roughness parameters determination by software package WinSPM NanoLab and therefore surface finishing quality. Determination of depth and height of the grooves and grains in topological image using the software package WinSPM NanoLab. Micromanufacturing in NanoLab. Fabrication of thin-film by vapour deposition method in NanoLab. Analysis of micro-and nano-manufacturing principles in the chosen example.

prerequisite

Student atends seventh semester.

learning resources

Handouts and presentations. The scanning microscope JSPM5200. The device for chemical vapor deposition CVD JEOL IEE 400. Conventional Machine Tools: Lathe Optimum Maschinen Germany Drehmaschine D180x300-Vario, Hogger Optimum Maschinen Germany-Bohr-BF20 L Vario FASMASCHINE, Drill Optimum maschinen-TISCHBOHRMASCHINE B17Pro Germany, Sander Optimum Maschinen Germany DUPPELSCHLEIFER OPTI-SM175, Roland CAMM Milling machine PNC2300-2.

number of hours

total number of hours: 45

active teaching (theoretical)

lectures: 12

active teaching (practical)

auditory exercises: 5
laboratory exercises: 4
calculation tasks: 4
seminar works: 9
project design: 0
consultations: 2
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 2
check and assessment of seminar works: 3
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 2
final exam: 2

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 30
laboratory exercises: 10
calculation tasks: 0
seminar works: 30
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

"Introduction to Microfabrication",S. Franssila, John Wiley & Sons Ltd, 2004.
"Microfabrication and Nanomanufacturing", Edited by M. Jackson,Taylor & Francis Group, 2006.
"Emerging Nanotechnologies for Manufacturing ", W. Ahmed, Elsevier, 2009.
"Nanomanufacturing Handbook" , A. Busnaina, Taylor&Francis group, 2007.
"Uvod u nanotehnologije", L. Matija, D. Kojić, A. Vasić, B. Bojović, T. Jovanović, Đ. Koruga, Nauka, Beograd, 2011.

New generation of machine tools and robots

ID: MSc-0331
teaching professor: Главоњић М. Милош
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: production engineering

goals

1. Perception of different levels of the new generation of machine tools and robots concept.
2. Acquisition of basics of reconfigurable, high-speed, meso- and micro-machines and high-accuracy machine tools.
3. Practical knowledge about parallel kinematic machines and machines for material addition processes and multi-axis machining.
4. Development of programming skills relevant for the new generation of machine tools and robots.
5. Development of report-making skills.

learning outcomes

1. Knowledge about the types and use of the new generation of machine tools and robots.
2. Knowledge about different levels of the new generation of machine tools and robots concept.
3. Skill to cope with the new generation of machine tools and robots environment and to choose and prepare those machines for operation.
4. Developed programming skills relevant for numerically controlled new generation of machine tools and robots.
5. Knowledge about new numerically controlled systems.

theoretical teaching

New teaching contents:
T1. Definition and classification of the new generation of machine tools and robots.
T2. Reconfigurable machine tools.
T3. High-speed machine tools.
T4. Machines for material addition processes.
T5. Parallel kinematic machines concepts.
T6. Identification of geometry and kinematics in parallel kinematic machines.
T7. Multi-axis machine tools.
T8. Multi-axis machining robots.
T9. Meso- and micro-machines.
T10. High-accuracy machine tools.
Extension:
(a) Extension of T1 and calculation tasks relevant for parallel kinematic machines geometry.
(b) Extension of T2 and calculation tasks relevant for parallel kinematic machines.
(c) Extension of T3 using the examples of meso- and micro-machines.
(d) Extension of T4 using the examples of machine tool calibration.
(e) Extension of T5 using the examples of compensations in the machining system.

practical teaching

Practical teaching involves auditorial exercises, laboratory work and seminar work writing.
1. Auditorial exercises: (1)Resources for studying the new generation of machine tools and robots. (2)Analysis of reconfigurable machines. (3)Machine tool calibration and compensations

in the machining system.
2. Laboratory exercises: (1)Programming of machines for material addition processes. (2)Programming of functional simulator for parallel kinematic machine. (3)Programming of parallel kinematic machines. (4)Programming of multi-axis machining. Instructions are provided for each exercise and the necessary work sheets.
3. A seminar work on the new generation of machine tools and robots.
4. A report is written on the knowledge acquired during the course according to instructions and model provided at the start of the course. A part of the report is a seminar work.

prerequisite

Study curriculum and student motivation for learning about machine tools and industrial robots according to the goals set and outcomes offered.

learning resources

1. W. R. Moore, Foundations of Mechanical Accuracy, The Moore Special Tool Company, First Edition, Third Printing, 1999.
2. Y. Ito, Modular Design for Machine Tools, McGraw-Hill, 2008, DOI: 10.1036/0071496602.
3. D. Kochan, Ed, Solid Freeform Manufacturing, Advanced Rapid Prototyping, Elsevier, 1993, ISBN 0-444-89652-X.
4. H. Schulz, Hochgeschwindigkeitsfraesen metallischer und nichtmetallischer Werkstoffe, Hanser Verlag, 1989, ISBN 3-446-15589-9.
5. K. Ehmann, D. Bourell, M. Culpepper, T. Hodgson, T. Kurfess, M. Madou, K. Rajurkar, R. DeVor, International Assessment of Research and Development in Micromanufacturing, Final Report, WTEC, 2005.
6. Tsai L.-W. (1999) Robot Analysis: The Mechanics of Serial and Parallel Manipulators, Wiley, New York.
7. Merlet J.-P. (2000) Parallel Robots, Kluwer Academic Publisher, Dordrecht, The Netherlands.
8. LPI-1: Two work-places equipped with prototypes of the new generation of machine tools (3-axis parallel milling machine, desktop 3-axis parallel milling machine).
9. LPI-2: Two work-places equipped with prototypes of the new generation of robots (serial machining robot, DELTA robot).
10. LPS-1: Functional simulators of parallel kinematic machines.
11. LPS-2: Functional simulator of the machine for prototype building.
12. CSP-1: Two work-places equipped with the software for programming of multi-axis machining.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 5
laboratory exercises: 21
calculation tasks: 0
seminar works: 4
project design: 0
consultations: 0
discussion and workshop: 0

research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 1
check and assessment of seminar works: 1
check and assessment of projects: 0
colloquium, with assessment: 3
test, with assessment: 5
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 50
laboratory exercises: 10
calculation tasks: 0
seminar works: 10
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

J. A. McDonald, C. J. Ryall, D. I. Wimpenny (Eds.), Rapid Prototyping Casebook, Wiley, 2001, ISBN: 978-1-86058-076-5.
R. I. Noorani, Rapid Prototyping: Principles and Applications, Wiley, 2005, ISBN 13: 978-0-471-73001-9.
S. S. Makhanov, W. Anotaipaiboon, Advanced Numerical Methods to Optimize Cutting Operations of Five-Axis Milling Machines, Springer, 2007, ISBN 978-3-540-71120-9.
L. C. Hale, Principles and Techniques for Designing Precision Machines, Ph.D. Thesis, 1999, Lawrence Livermore National Laboratory, UCRL-LR-133066.
N. Taniguchi, T. K, K. M, K. I, I. M, T. D. (Eds.), Nanotechnology, Integrated Processing Systems for Ultra-precision and Ultra-fine products, Oxfod University Press, 1996, ISBN10: 0198562837.

New Technologies

ID: MSc-0104
teaching professor: Пузовић М. Радован
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: production engineering

goals

The aims of introducing new technologies to production are top quality products, low-cost and short-time manufacturing process. This course is intended for students of the Production Engineering Department. Students are familiarized with modern technologies that make possible to extend knowledge acquired in Manufacturing Technology and Production Technologies and Metrology.

learning outcomes

Having successfully mastered the teaching contents of New Technologies, the student should be able to: design technology for building complex machine parts, design technology for manufacturing of cutting tools, tools for processing plastic masses, forging tools, supply and maintenance of accessories.

theoretical teaching

AN-1: Introduction to new technologies; AN-2: Contemporary tools and tool materials; AN-3: Technology of synthesis; AN-4: Finish cutting technologies; AN-5: Machining technology by abrasive suspension; AN-6: Technology of powder metallurgy; AN-7: Technology of polymer shaping; AN-8: Forging technology; AR-1: Consolidation of teaching contents through presentation of new technologies; AR-2: Survey of contemporary cutting tools and tool materials application; AR-3: Demonstration of technology of synthesis; AR-4: Consolidation of teaching contents related to finish cutting methods; AR-5: Giving instructions for the design of tools for building machine parts from plastic masses; AR-6: Giving instructions for forging tools design;

practical teaching

PP-1: Design of tools for building machine parts from plastic masses or forging tools design (students opt for the design of one of the offered tools); PL-1: Standard and special cutting tools (tool material, geometrical shapes of tools, tool assembly, and tool use); PL-2: Application of machining technology by abrasive suspension (demonstration on concrete examples); PL-3: Tools for building machine parts from plastic masses (components, molding systems, assembly, exploitation characteristics; PL-4: Forging tools (components, casting systems, assembly, exploitation characteristics).

prerequisite

Defined by the Study Program Curriculum

learning resources

1. Handouts (PDF files) (18.) /In Serbian/
2. Kalajdžić M., Manufacturing technology, FME, Belgrade, 2005 (18.2) /In Serbian/
3. Laboratory equipment (tools and machines) at IMT (18.12)

4. SAx software work station (CAD, CAM, CAE, CAPP,...), (CAX) (18.13)

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 0
laboratory exercises: 12
calculation tasks: 0
seminar works: 0
project design: 18
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 4
check and assessment of seminar works: 0
check and assessment of projects: 2
colloquium, with assessment: 0
test, with assessment: 4
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 40
laboratory exercises: 10
calculation tasks: 0
seminar works: 0
project design: 15
final exam: 30
requirements to take the exam (number of points): 40

references

Handouts (PDF files) (18.) /In Serbian/
Kalajdžić M., Manufacturing technology, FME, Belgrade, 2005 (18.2) /In Serbian/
Laboratory equipment (tools and machines) at IMT (18.12)
SAx software work station (CAD, CAM, CAE, CAPP,...), (CAX) (18.13)

PRODUCTION INFORMATION SYSTEMS

ID: MSc-0306
teaching professor: Бојанић О. Павао
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: production engineering

goals

1.Acquisition of nowledge about the role and importance of computer-oriented information systems for planning and management of production systems
2. Mastery of theoretical basics of contemporary information systems architecture
3. Acquisition of practical knowledge for applications design and development in the domain of information systems for planning and management of production systems

learning outcomes

The student should acquire fundamental knowledge of:
1. computer-oriented information systems design and development
2. contemporary database application
3. contemporary software tools in the production information systems design and development
4. applications design and development for planning and management of production system subsystems.

theoretical teaching

Information systems for new concepts of production systems. Possible creation of contemporary concepts, such as CIM/CIE, TQM, Kanban system or MRP-II systems, as well as concepts of organizational structures, such as concepts of virtual enterprises, network production, e-production systems based on architectures of the system in the network environment. Processes in the client/server architecture are also the subject-matter of the course. Production system functional structure, its structuring primarily into subsystems of a production technological system: structural information management, technological information management, stock management, current business operations management, tools system management, transport management, maintenance management, all implying information modeling, database modeling, defining the object-link diagrams (EP diagram), DBMS choice, developing physical data model up to the application development level

practical teaching

The student acquires practical knowledge for the design and development of software applications in the domain of production systems planning and management. Using some of the available software tools for creating a database, the student passes through all stages of developing new software application for a concrete subsystem. This means the analysis of defined functions of planning and management, design and detailed elaboration of the designed solution, its practical realization, testing and official presentation in front of the teacher and other students

prerequisite

There are no prerequisites

learning resources

Handouts in e-form /In Serbian/. Instructions for laboratory exercises /In serbian/. Instructions for project design /In Serbian/. One-student-one-computer scheme in a computer room. Software tool for application development (Oracle, MS Access, Progress,...)

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 0
laboratory exercises: 15
calculation tasks: 0
seminar works: 0
project design: 15
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 3
colloquium, with assessment: 0
test, with assessment: 7
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 20
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 30
final exam: 40
requirements to take the exam (number of points): 40

references

Project Management

ID: MSc-0316
teaching professor: Спасић А. Жарко
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: production engineering

goals

Management and design in professional project teams. Documented technical system design. Professional communication using design solutions. Presentation of design solutions. Define the budget of projects and budget management. Project management by professional software. Dissemination and application of project results.

learning outcomes

Understand the purpose of the project and the task of a multidisciplinary project team. Negotiate with the user of the research and defines design task. Analyze existing and design new solutions. Successfully present design solutions. Manages project team. Define the project budget and funding sources. Use project management software. Ensures the implementation and further dissimination of solutions.

theoretical teaching

Tasks and goals of the project. Designing systems and processes. Projects in teaching and research. European Research Area. Programs of research and foundations. Europe-2010 based on knowledge. Priorities in research. Theory of network planning. Concepts and procedures of project management. Risk analysis. Project-oriented teaching. Project-oriented company. Project proposal and selection of criteria. Matrix of logical framework design. Indicators of progress of the project. Control points of the project. Working schedule and assignments. Management and coordination of projects. Responsibility and ethics in design. Evaluation of research units and researchers. Documentation of project. Contracting projects and budgets. Management of individual and complementary projects. Allocation and management of projects resource.

practical teaching

Defining the project task. The constitution of the project team. Consortium of universities and industry. Synthesis of partial design solutions. Format documenting and culture of project documenting. Documentation and electronic exchange of information. Training for project management. Public presentation of students design solutions. Standard software for project management. Simultaneous design and communications project subteams. Reports on the project - the partial and final. Monitoring of the project. Presentation of project.

prerequisite

Defined in the curriculum of study program/module.

learning resources

Spasić, Ž., integrated system of quality of digital university, MF, 2007.
Spasić, Ž., Information integration of business functions, Textbook, MF, 2009.
Spasić, Ž. et al., Faculty of Mechanical Engineering, University of Belgrade - The mission of the

path to European integration, MF, 2003.
Faculty of Mechanical Engineering: Alumni Fund of Faculty of Mechanical Engineering - αMEβ, Editors Ž. Spasić et al. The first Alumni Congress, 2005.
Faculty of Mechanical Engineering: Alumni Fund of Faculty of Mechanical Engineering - αMEβ, Editors Ž. Spasić et al. The second Alumni Congress, 2007.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 0
laboratory exercises: 8
calculation tasks: 4
seminar works: 6
project design: 10
consultations: 2
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 1
check and assessment of lab reports: 1
check and assessment of seminar works: 2
check and assessment of projects: 2
colloquium, with assessment: 2
test, with assessment: 2
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 15
laboratory exercises: 10
calculation tasks: 10
seminar works: 10
project design: 10
final exam: 40
requirements to take the exam (number of points): 37

references

Quality Management

ID: MSc-0448
teaching professor: Мајсторовић Д. Видосав
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: production engineering

goals

1.The aims of the course are to familiarize the student with goods and services quality management, necessary for each engineer in his practical and research work. 2. The student should acquire new knowledge and develop new skills in:
- basic concepts, development and models of quality management (QM),
- techniques for quality engineering (TQE) and their application,
- research activities in TQE,
- demands and application of ISO 9000 in practice,
- demands of our economy for cooperation with EU and modes of meeting those demands in practice.

learning outcomes

Having successfully mastered the teaching contents of Quality Management, the student should be able to understand and solve issues of contemporary approaches to QM using systemic approach to business and technological systems. The student should be competent of applying the latest generations of QM. The student should be capable of managing the processes of structuring our economy, as demanded by business operations related to QM at the markets of developed countries.

theoretical teaching

Theoretical teaching embraces 8 units:
1. Definition of product quality in a business/technological system. Definition of QM. Development of system approaches to QM (from inspection to excellence). Holistic approach.
2. Techniques for quality engineering. Definition. Classification and application. Analysis and synthesis of processing errors.
3. Statistical methods and QM. Method of layout curve analysis.
4. Control charts – definition, classification, structure. Control charts – application and analysis.
5. Acceptance plan – definition, classification, application. Measuring chains.
6. ISO 9000. Process models. QM principles. ISO 9001 – Requirements/Application. Certification. ISO 9004 – permanent improvements.
7. ISO 9001 /Small and middle businesses – application. Total quality management (TQM). Quality awards.
8. Business excellence. Models and application.

practical teaching

1.Five auditorial exercises concerning the application of TQE in practice (processing accuracy, methods of quality statistical control) and ISO 9000.
2. Two laboratory exercises (modeling of TQE problems and solving them by using software NIST-CAD.
3. Six calculation tasks in engineering analysis and synthesis of TQE application. 4. QM in practice – discussion and workshop (a visit to a plant and familiarizing with how ISO 9000

functions practically).

prerequisite

Obligatory: Courses attended at BSc, FME or other technical faculties.
Desirable: Elective courses of BSc (undergraduate) Academic Studies.

learning resources

1.Handouts for each lecture. /In Serbian/
2. Instructions for doing homework assignments and laboratory exercises. /In Serbian/
3. Textbook: Quality management (in preparation) /In Serbian/
4. Quality Management site containing materials from 1. and 2. learning resources and links to leading organizations and institutions in the respective area.
5. Technical instruments – Laboratory for production metrology and TQM with equipment and licensed software necessary for this course.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 14
laboratory exercises: 5
calculation tasks: 11
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 4
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 6
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 30
laboratory exercises: 0
calculation tasks: 20
seminar works: 0
project design: 0
final exam: 40
requirements to take the exam (number of points): 36

references

Handouts for each lecture. /In Serbian/
Instructions for doing homework assignments and laboratory exercises. /In Serbian/
Textbook: Quality management (in preparation) /In Serbian/
Quality Management site containing materials from 1. and 2. learning resources and links to leading organizations and institutions in the respective area.
Technical instruments – Laboratory for production metrology and TQM with equipment and licensed software necessary for this course.

Quality System and Integrated Managemet Systems

ID: MSc-0222
teaching professor: Мајсторовић Д. Видосав
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: production engineering

goals

1.Acquisition of new knowledge about standardized management systems and good practice in diverse areas and sub-systems of manufacturing-technological systems. 2. Acquisition of knowledge and development of skills in:
- basic concepts, development and management system standardized models,
- demands and application of these systems in practice,
- investigations in the IMS area,
- further development of these models.

learning outcomes

Having successfully mastered the contents of this course, the student should be able to understand and solve problems concerning contemporary approaches to quality management and other standardized models based on systemic approach in business and technological systems. The knowledge acquired will assist future engineers in our economy management, business operations' demands at EU markets and those of other developed countries, relevant to standardized management systems.

theoretical teaching

Theoretical teaching comprises 10 teaching units:
1. Development of systemic approach to quality management (QM). The QM principles. ISO 9000 and the models derived (AS, TL, VDA 6.1, ISO 16949, ISO 13485...).
2. ISO 9000/9001/9004. Models and demands. Application. Continuous upgrading.
3. ISO 14000, OHSAS 18001, ISO 19011. Models and demands. Application. Sustainable development.
4. ISO 22000 series. The NASSR concept. Models, demands and application.
5. Laboratories accreditation. Models ISO 17025/15189. Models, demands, application.
6. ISO 27001, ISO/IEC 15408, BS 6072. Good manufacturing, laboratory, packing and transport practices (GMP/GLP/GPP/GTP).
7. EU directives and CE marking. Structure, demands, integration and application. 8. Certification/accreditation system (national/international). Quality national/EU infrastructure. Models and practical application.
9. Integrated management systems (IMS). PAS 99 – integration and structure.
10. IMS design. IMS documentation and structure. Further IMS development.

practical teaching

1.IMS project design for a company. For the concrete company, IMS project involves: Analysis of standard demands based on the demands of the company's business operations; IMS structure design; Defining the IMS information structure and development of IMS documentation (one level); Example creation and pilot test; Public presentation of the project e-version, its defense and discussion.
2. IMS in practice – discussion and workshop. How to approach and realize IMS project in practice. Possible problems and how to overcome them.

prerequisite

Compulsory: Courses of BSc academic studies.
Desirable: Elective courses of BSc academic studies.

learning resources

1. Handouts for each teaching unit /In Serbian/
2. Instructions for homework assignments and laboratory exercises /In Serbian/
3. Integrated management systems (Textbook) /In Serbian/
4. Web site for this course contains materials for 1. and 2. and a list of references as well as links to relevant sites.
5. Technical equipment – Lab for manufacturing metrology and TQM that has adequate equipment and licensed software.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 30
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 4
colloquium, with assessment: 0
test, with assessment: 6
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 30
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 20
final exam: 40
requirements to take the exam (number of points): 36

references

Handouts for each teaching unit /In Serbian/
Instructions for homework assignments and laboratory exercises /In Serbian/
Integrated management systems (Textbook) /In Serbian/
Web site for this course contains materials for 1. and 2. and a list of references as well as links to relevant sites.
Technical equipment – Lab for manufacturing metrology and TQM that has adequate equipment and licensed software.

Sheet-Metal Processing Tools

ID: MSc-0322
teaching professor: Тановић М. Љубодраг
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: production engineering

goals

Acquisition of theoretical and practical knowledge in the domain of the design, calculations and construction of tools for sheet-metal processing by punching, drilling, bending, drawing, and combination of these methods. The student acquires a sound understanding of the importance of team work and cooperation in the area of the design based on contemporary technologies and optimal solution.

learning outcomes

1.Fundamental knowledge of sheet-metal processing tools. 2. Know-how the approach to the design process. 3. Sound knowledge and understanding of the process. 4. Fundamental practical knowledge of tools' realization in industry.

theoretical teaching

The mathematical theory of plasticity and physics of plastic deformation in solids (hypotheses and models of solids). Plastic deformation mechanism. Continuum mechanics. Elastic repositioning of sheet metal. Deformation force and work in processing by punching, drilling, bending, drawing. Determination of the sheet-metal holder force. Determination of the press force. Determination of the tool pressure center. Determination of preliminary work-piece measurements for components manufactured by bending and drawing. Determination of the sequence and number of operations. Construction characteristics of tool working elements.

practical teaching

During laboratory exercises the student is acquainted with practical realization of sheet-metal processing tools. Project design for a concrete practice-related work-piece. Tools for making normal-accuracy components. Single-operating, multiple-operating and combined tools. Tools for making ribs for smaller or larger hole shaping. The hole enlargement by edge drawing. A visit to the factory where students are acquainted with the tool making technological process. Acquainting students with recommendations from practice relevant to tool design.

prerequisite

Defined by the Study Program Curriculum

learning resources

1. Standardized tool elements, Sheet-metal processing tool elements, Lab for FTS, machining processes and tools, ЛПС

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 2
laboratory exercises: 10
calculation tasks: 0
seminar works: 0
project design: 14
consultations: 4
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 6
colloquium, with assessment: 0
test, with assessment: 4
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 20
laboratory exercises: 10
calculation tasks: 0
seminar works: 0
project design: 20
final exam: 40
requirements to take the exam (number of points): 30

references

Jovičić M., Tanović Lj., TOOLS AND TOOLING FIXTURES - calculations and constructrions of sheet-metal processing tools, FME, Belgrade, 2007, КПН

SKILL PRAXIS M – PRO

ID: MSc-0542
teaching professor: Живановић Т. Саша
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 1
final exam: seminar works
parent department: production engineering

goals

The student gains practical experience and gets familiarized with the future occupational environment. The student identifies basic functions of the business system in the domain of design, development and manufacturing as well as the role and tasks of the mechanical engineer within such a business system.

learning outcomes

Students should become proficient in the manner of organizing and functioning of the environment where they will apply the acquired knowledge in their future career. Students can identify the models of communication with the colleagues and business information flow. They can also identify basic processes in the design, manufacturing, maintenance within the context of their future competences. Establishment of contacts and acquaintances are useful during graduate studies as well as for applying for the job in the future.

theoretical teaching

practical teaching

Practical teaching means work in the companies where various activities related to mechanical engineering are proceeding. The subject matter and business company or research institution is selected in consultation with the professor. In principle, the student is allowed to conduct skill praxis in manufacturing companies, design and consulting firms, enterprises for machine equipment maintenance, public enterprises and municipal service companies or any laboratory at FME. Skill praxis can also be performed abroad. Students are obliged to keep a diary of skill praxis, where they describe the jobs they are doing, write down deductions and perceptions. Having completed the skill praxis the students must make a report they will defend in front of the professor. The report is handed over in the form of a seminar work.

prerequisite

Defined by the Study Programm Curriculum

learning resources

number of hours

total number of hours: 46

active teaching (theoretical)

lectures: 0

active teaching (practical)

auditory exercises: 0

laboratory exercises: 41
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 0
laboratory exercises: 70
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 50

references

Kalpakijan, S., Manufacturing Engineering and Tehnology, Addison-Wesley Publishing Company, 1989.

railway mechanical engineering

Brakes of rail vehicles

ID: MSc-0246
teaching professor: Симић Ж. Горан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: railway mechanical engineering

goals

1. Introducing the brake system of railway vehicles.
2. Acquiring the knowledge necessary to understand the functioning of rail vehicle brake system components.
3. Training for the application of knowledge in the design, development, repair and maintenance of the brakes.

learning outcomes

After completion of the course the student should be able to:
1. Explain the functional and design characteristics of various types of brakes.
2. Explain the tasks and functioning mode of brake system assemblies.
3. Identify actions required to be aplied in case of malfunctions of the break system during operation and maintenance.
4. Apply appropriate regulations and standards for design and maintenance of rail vehicle brakes.

theoretical teaching

The general braking conditions. Friction and friction materials. The main types of brakes and braking techniques. The transfer of the braking action by means of the compressed air. The main braking conditions. Transmission speed, transmission time, braking time and release time. The process of braking. Braking, brake weight, weight at changeover. The stopping distance and stopping time. Braking tables. Adjusting the brake force to the load. Thermal and other restrictions of the braking force. Emergency brake. Handbrake. Electromagnetic rail brakes. UIC regulations relating to the brakes of railway vehicles. Braking modes RIC, R, S, SS ... The calculation of the brakes for passenger and freight cars. Formation and tansmission of the braking force: compressor with accessories, the main pipe, tanks, distributor, brake cylinder, mechanical transmission, slack adjuster. Executive parts: brake holders, brake shoes, discs, calipers, brake pads, other accessories. Testing of brakes: type and serial tests of the brakes and brake equipment. Experimental determination of the braking power.

practical teaching

Clasification of the brakes. Functional scheme of basic types of brakes. Functional scheme of pneumatic brakes. The working principle of control valve. The working principle of the distributor valve. Brake system schemes for typical rail vehicles. Gear ratio and the coefficient of efficiency. The design of the brake with brake shoes. Braking parameters selection based on regulations. The design of disc brakes. Visit the workshop for the brake maintenance. Braking tables. Examples of calculation. Examples of braking mass determination based on the brake stopping distance tests. Calculation of brake mass. Calculation of the handbrake. The design of the braking force transmission elements. The design of magnetic rail brakes, parking brake, emergency brake. Brakes for high-speed trains.

prerequisite

It is recommended previously to pass course Railway vehicles 1.

learning resources

Milovanović, M., Lišanin, R., Brakes and braking of rail vehicles (in Serbian),
For tasks realisation shall be used the appropriate regulations and standards.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 14
laboratory exercises: 0
calculation tasks: 7
seminar works: 0
project design: 0
consultations: 4
discussion and workshop: 5
research: 0

knowledge checks

check and assessment of calculation tasks: 6
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 4
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 30
laboratory exercises: 0
calculation tasks: 30
seminar works: 0
project design: 0
final exam: 40
requirements to take the exam (number of points): 30

references

Elective skill praxis M / ŽEM

ID: MSc-0135
teaching professor: Симић Ж. Горан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 1
final exam: seminar works
parent department: railway mechanical engineering

goals

Gain of practical experience in an environment where the student will realize his or her professional career.
Recognizing the basic functions of the system in the field of design, development and production. Consideration of the roles and tasks of mechanical engineering in such a system.

learning outcomes

theoretical teaching

practical teaching

Practice includes work in companies which perform various activities related to mechanical engineering. Selection of thematic and company will be conducted in consultation with the concerned teacher. Generally a student can perform practice in production companies, design and consulting organizations, organizations concerned with maintenance of rolling stock, rail transport companies or , exceptionally, in some of the labs of the faculty. During practice, student should make notes with description of the work performed, conclusions and observations. After performing practice, these notes should be transformed in the practice report. Report will be defended in front of other students and the teacher.

prerequisite

learning resources

number of hours

total number of hours: 46

active teaching (theoretical)

lectures: 0

active teaching (practical)

auditory exercises: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 0
final exam: 46

assessment of knowledge (maximum number of points - 100)

feedback during course study: 70
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

Elective skill praxis M - ŽEM

ID: MSc-0488
teaching professor: Лучанин Ј. Војкан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 1
final exam: project design
parent department: railway mechanical engineering

goals

Students practical experience and stay in the environment in which the student will realize his professional career. Identifying the basic functions of the business system in the field of development, designing, production, maintenance of railway vehicles, as well as the roles and tasks of mechanical engineer in such a business system.

learning outcomes

Students get practical experience on the organization and functioning of the environment in which they will apply their knowledge in their future professional career. Student identifies models of communication with colleagues and business information flows. The student recognizes the basic processes in the designing, manufacturing, maintenance, in the context of his future professional competence. Establish the personal contacts and acquaintances that will be able to use at school or entering into future employment.

theoretical teaching

Introduce students to practical training realization concept ant prepare them for all units of prescribed curriculum and way of communication. Guidelines for diary keeping and report writing are given and students record are created.

practical teaching

Practical work involves work in organizations with various activities in relations with mechanical engineering. Selection of thematic areas, commercial or research organizations students carrier out in consultation with the relevant teacher. Generally a student can perform the practice in manufacturing organizations, project and consulting organizations, organizations for maintenance of railway vehicles and in some of the laboratories at Faculty of Mechanical Engineering. The practice may also be done abroad. During practice, students must keep a diary in which have to enter a description of the tasks performed, the conclusions and observations. Following the practice must make a report which have to present to the relevant teacher. The report is submitted in the form of the paper.

prerequisite

Nothing

learning resources

Guide for keeping a practice diary and writing final report.

number of hours

total number of hours: 46

active teaching (theoretical)

lectures: 0

active teaching (practical)

auditory exercises: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 0
final exam: 46

assessment of knowledge (maximum number of points - 100)

feedback during course study: 70
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

Fundamentals of Rail Vehicle Dynamics

ID: MSc-0453
teaching professor: Симић Ж. Горан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: railway mechanical engineering

goals

1. Acquiring knowledge about the dynamic behavior of rail vehicles.
2. Exploring methods for studying the dynamic behavior of rail vehicles.
3. Training for the application of knowledge in the design, development, repair and maintenance of railway vehicles.

learning outcomes

After completion of the course the student should be able to:
1. Explain the characteristic phenomena of dynamic behaviour of rail vehicles.
2. Apply computational methods for determining the main parameters of the dynamic behaviour of the rail vehicles.
3. Participate in the preparation of the test procedures for tests of the dynamic behaviour and proper assesment of the test results.
4. Apply appropriate regulations for building or refurbishment of rolling stock in order to achive the prescribed dynamic behaviour.

theoretical teaching

Modeling of the dynamic behaviour of the rail vehicles. Geometrical deviations of the track and deviations of wheelset geometry as the excitation source. An elementary model of the vertical oscillation of vehicles with single-stage suspension. The appearance of resonances during movement along track with vertical harmonic deformations. The influence of damping. The behavior of vehicles with dry damping elements. Model of the railway vehicle with two-stage suspension in vertical direction. Application of matrix calculus in solving the dynamic problems. Fundamentals of rail vehicle lateral dynamics. A hunting movement of the wheelset- Klingel solution. The contact geometry. Equivalent conicity. The forces in the wheel-rail contact. The movement of bounded wheelset. Stability of motion. Critical speed. Modelling of stationary, quasistatic motion of the bogie in the curve using the center of friction method. Criteria for assessing the behavior of rail vehicles in motion. (Y/Q) criterion. Criterion of the H forces. Sperlings criteria. Tests according to UIC 518. Criteria ISO/ORE (UIC518).

practical teaching

Examples of excitation: denivelation of the rails, out off roundness and eccentricity of the wheel, track deformations, harmonic deformations. Excitation simulation. Linear and nonlinear characteristics of elastic and damping elements. Linearisation of the characteristics. Examples of one degree of freedom models. Typical dry friction elements used on rail vehicles. The model with dry friction. Example of two axle bogie model in the vertical plane. Effect of selection of generalized coordinates to eqution coupling. Example of the freight wagon model with bogies. Example of model of passenger coach two-stage suspension in the vertical plane. Solving problems with more degrees of freedom using computer software. Review of tests of passenger coache dynamic behaviour.

prerequisite

Previously passed courses in Mechanics of rigid bodies and at least 18 EPSB, with at least one course of Dynamics.

learning resources

G. Simić, Fundamentals of rail vehicle dynamics, hand-out.
User guides for appropriate software.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 15
laboratory exercises: 0
calculation tasks: 11
seminar works: 0
project design: 0
consultations: 4
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 6
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 4
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 40
laboratory exercises: 0
calculation tasks: 30
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

Locomotive 1

ID: MSc-0243
teaching professor: Лучанин Ј. Војкан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: railway mechanical engineering

goals

1. Introduction student to the basic concepts important for understanding the designing of diesel locomotives.
2. Knowledge acquiring necessary for understanding the designing of diesel locomotives.
3. Competence for use the knowledge acquired in solving practical problems in designing, use and maintenance of diesel locomotives.

learning outcomes

In the end of the course student should be able to:
1. Explains basic concepts concerning diesel locomotives.
2. Explains tasks and operation mode of diesel locomotives.
3. Accomplish certain calculations concerning diesel locomotives.
4. Apply certain standards and regulations in the field of diesel locomotives.
5. Use computers tools for certain calculation of diesel locomotives.

theoretical teaching

Brief history, Overview of historical development and traction vehicles basic characteristics, High speed vehicles, Influential factors on adhesion, Traction force, Resistance during motion, Basic conception of diesel traction vehicles, Introductions with the basic framework, Design of the running bogie and the supporting vehicle structure, Diesel motor - specification of diesel motors for railway vehicles, Power supply characteristics, Modern motors for railway vehicles, Examination and emission of exhaust gases, Characteristics of units for power transmission on railway vehicles, Design of mechanical transmitters, Design of hydrodynamic transmitters, Joint operation of diesel motor and hydrodynamic transmitter, Design of cooling systems.

practical teaching

Practical training, Auditory exercises (Introductions with examples regarding learned materials - Modern solutions of diesel motors for railway vehicles, Mechanical transmitters for railway vehicles, Hydraulic - hydrostatic and hydrodynamic transmitters for railway vehicles, Regulation of diesel motor and transmitter joint operation, Accessories on diesel locomotives), Solving the set problem (Designing of diesel hydraulic locomotives power supply systems), Introductions with practical problems in the field of inspection and maintenance of diesel locomotives, Visiting the factory for production of diesel locomotives, Discussion and workshops.

prerequisite

Nothing

learning resources

Syllabus, Guidebook for solving the tasks, Handouts, Personal PC, Projector and internet access

- internet exploring for additional information's.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 15
laboratory exercises: 0
calculation tasks: 5
seminar works: 0
project design: 0
consultations: 5
discussion and workshop: 5
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 5
test, with assessment: 5
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 30
laboratory exercises: 0
calculation tasks: 10
seminar works: 15
project design: 0
final exam: 35
requirements to take the exam (number of points): 35

references

Karl Sachs, Elektrishe Triebfahrzeuge, Springer-Verlag, Wien New York, 1973
Zdravko Valter, Diesel - electric locomotive, Školska knjiga, Zagreb, 1985

Locomotive 2

ID: MSc-0230
teaching professor: Лучанин Ј. Војкан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: railway mechanical engineering

goals

1. Introduction student to the basic concepts important to understanding the the designing of diesel-electric and electric locomotives.
2. Knowledge acquiring necessary for understanding the designing of diesel-electric and electric locomotives.
3. Competence for use the knowledge acquired in solving practical problems in designing, use and maintenance of diesel-electric and electric locomotives.

learning outcomes

In the end of the course student should be able to:
1. Explains basic concepts concerning diesel-electric and electric locomotives.
2. Explains tasks and operation mode of diesel-electric and electric locomotives.
3. Accomplish certain calculations concerning diesel-electric and electric locomotives.
4. Use computers tools for certain calculation of diesel-electric and electric locomotives.
5. Apply certain standards and regulations in the field of diesel-electric and electric locomotives.

theoretical teaching

Brief history, Overview of historical development and basic characteristic traction vehicles, High speed vehicles, Influential factors on adhesion, Traction force, Resistance during motion, Basic conception of diesel traction vehicles, Introductions with basic frame, Design of the bogie and the frame, Diesel motor - specification of diesel motors for railway vehicles, Power supply characteristics, Modern motors for railway vehicles, Examination and emission of exhaust gases, Characteristics of units for power transmission on railway vehicles, Design of mechanical gear, Design of hydrodynamic gear, Diesel motor and hydrodynamic gear working together, Design of cooling systems.

practical teaching

Practical training, Auditory exercises (Introductions with examples regarding learned materials - Modern solutions in the field of electric machines , Generators and Traction motors, Adjustments technique), Solving the set problem (Designing of diesel locomotives power supply systems), Introductions with practical problems in the field of inspection and maintenance of electric locomotives, Practical examples in the field of the electrical vehicles speed regulation - thyristors regulation, transducer. Visiting the maintenance shop for the electric locomotive. Exploring the traction vehicles components. Discussion and workshops.

prerequisite

Attended the course Locomotive 1.

learning resources

Syllabus, Guidebook for solving the tasks, Handouts, Personal PC, Projector and internet access - internet exploring for additional information's.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 15
laboratory exercises: 0
calculation tasks: 5
seminar works: 0
project design: 0
consultations: 5
discussion and workshop: 5
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 5
test, with assessment: 5
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 30
laboratory exercises: 0
calculation tasks: 10
seminar works: 15
project design: 0
final exam: 35
requirements to take the exam (number of points): 35

references

Karl Sachs, Elektrishe Triebfahrzeuge, Springer-Verlag, Wien New York, 1973
Zdravko Valter, Diesel - electric locomotive, Školska knjiga, Zagreb, 1985

Rail vehicles 1

ID: MSc-0282
teaching professor: Симић Ж. Горан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: railway mechanical engineering

goals

1. Understanding different constructions of the freight wagons and passenger coaches
2. Acquiring the knowledge necessary to understand the functioning of wagon or coach assemblies
3. Application of knowledge in the design, development, repair and maintenance of wagons and coaches

learning outcomes

After completion of the course the student should be able to:
1. Explain the functional and structural characteristics of various types of rolling stock.
2. Explain the tasks and functioning principles of the assemblies of the rail vehicles.
3. Identify actions required to resolve failures in operation and maintenance of rail vehicles.
4. Apply appropriate regulations and standards for design and maintenance of railway vehicles.
5. Applicate computer tools for calculating and designing rail vehicles.

theoretical teaching

General fundaments for designing rail vehicles. Main assemblies of the rail vehicles. The structural parameters of the vehicle. Standards and regulations in the design, operation and maintenance of rail vehicles. Wheelsets. Axle bearings. Single axis running gear. Typical bogies for wagons. Bogies for passenger coaches. Bogie breakaway torque. Running gear with independent wheels. Calculation of the rail vehicles gauge. Flexibility coefficient. Checking the relative position of the running gear agaginst carbody. General overview of the loads acting on the structure of the wagon. Unbalanced lateral acceleration. Calculation of the rail vehicle rollover safety. Calculation loads for axle strength.
Design of the carbody bearing structure. Materials for the bearing structure. Regulations for design loads and alowable stresses for carbody and for bogie frame. Strength calculation. Strength test. Passive safety measures for the crash scenario.

practical teaching

Division of rail vehicles. Selection of basic parameters and their constraints. The examples and analysis of excerpts from the regulations. Characteristic wheel profile measurments. Pressed-on or shrunk-on fitting of wheelsets and shrunk-on fitting of the wheel tyers on wheel centres. Examples of axle bearing assemblies. Design of typical freight wagon bogies. Design of passenger coach bogies. Vehicle gauge calculation. calculation of relative position running gear/carbody. General vehicle load determination.
Calculation of carbody bearing structure. Checking the stability of the bearing elements of the structure.
Fundamentals of stress measuring techniques. Procedure for strength testing of the carbody.

prerequisite

Previously finished equivalent of at least: 12 ECTS in Mechanics of rigid bodies, 6 ECTS in

Mechanic of deformable bodies and 6 ECTS Machine elements.

learning resources

G. Simic, Rail vehicles, hand-out
G. Simic, Instructions for writing student papers, hand-out
For preparation tasks as a basis should be used the appropriate regulations and standards

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 11
laboratory exercises: 0
calculation tasks: 0
seminar works: 3
project design: 8
consultations: 3
discussion and workshop: 5
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 6
colloquium, with assessment: 4
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 30
laboratory exercises: 0
calculation tasks: 0
seminar works: 5
project design: 30
final exam: 35
requirements to take the exam (number of points): 40

references

Railway vehicles 2

ID: MSc-0245
teaching professor: Симић Ж. Горан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: railway mechanical engineering

goals

1. Understanding different constructions of the freight wagons and passenger coaches
2. Acquiring the knowledge necessary to understand the functioning of wagon or coach assemblies
3. Application of knowledge in the design, development, repair and maintenance of wagons and coaches

learning outcomes

After completion of the course the student should be able to:
1. Explain the functional and structural characteristics of various types of rolling stock.
2. Explain the tasks and functioning principles of the assemblies of the rail vehicles.
3. Identify actions required to resolve failures in operation and maintenance of rail vehicles.
4. Apply appropriate regulations and standards for design and maintenance of railway vehicles.
5. Applicate computer tools for calculating and designing rail vehicles.

theoretical teaching

General characteristics of the elastic suspension system. Suspension with helical springs. Suspension with leaf springs. Suspension with rubber springs. Air suspension system. Elastic pendulum-based systems. Natural and forced tilt of the rail vehicles in curves. Torsional characteristics of the rail vehicles. Damping elements. Active and passive suspension systems. Draw-buff gear. Design and mechanical characteristics of buffers. Draw gear. Automatic couplers. Equipment of the passenger coaches. Doors, windows, stairs. Heating and air conditioning requirements and design performance. Electrical installation. Passenger information system. Fire protection. Noise inside the vehicle and noise emission. Specifics of passenger coaches for high speeds. Specifics of the freight wagons for increased speeds.

practical teaching

Initial requirements and general constraints for design of the elastic suspension system. Design of suspension springs szstem with double ring links. design of the szstems with helical springs. Design of the szstems with rubber springs. Air suspension system design. Determination of the torsional characteristics of the rail vehicle. Design of the anti roll system. Active and passive tilt systems.
Design of buffers. Limitation of space on the ends of the wagon. Calculation of the buffer plates dimensions. Calculation of the draw gear angular deflection in curves. Intercirculation devices of passenger coaches. Examples of design solutions for different equipment of the wagons.

prerequisite

Previously passed course Railway vehicles 1.

learning resources

G. Simic, Rail vehicles, hand-out
G. Simic, Instructions for writing student papers, hand-out
For preparation tasks as a basis should be used the appropriate regulations and standards

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 6
laboratory exercises: 2
calculation tasks: 0
seminar works: 3
project design: 9
consultations: 5
discussion and workshop: 5
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 6
colloquium, with assessment: 4
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 30
laboratory exercises: 0
calculation tasks: 0
seminar works: 5
project design: 30
final exam: 35
requirements to take the exam (number of points): 40

references

Railway vehicles maintenance

ID: MSc-0234
teaching professor: Лучанин Ј. Војкан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: railway mechanical engineering

goals

Upon completion of the course the student should be able to:
1. Explain the basic concepts related to the reliability of rail vehicles.
2. Explain the basic concepts related to the maintenance of rail vehicles.
3. Explain the tasks and practices of the workshop for the maintenance of railway vehicles.
4. Perform appropriate calculations related to maintenance of rail vehicles.
5. Apply appropriate tools for computer calculations of electric and diesel electric locomotives.

learning outcomes

1. Understanding the basic concepts important for understanding the reliability and maintenance of rail vehicles.
2. Acquiring the knowledge necessary to understand the problems of maintenance of rail vehicles.
3. Preparation to implement the acquired knowledge in solving practical problems in maintaining the railway vehicles related to the organization, implementation and projected activities in the field of application of knowledge and information and the reliability of expert systems.

theoretical teaching

Theoretical basis of reliability.Prediction reliability.Methods of determining the distribution of the data set.Setting reliability requirements and measures for their achievement for rail vehicles.The concept of constructing the basis of reliability. Maintenance of technical systems.Engineering maintenance.Maintenance and life cycle of railway vehicles.Maintenance process.Overview of the developed concept of maintenance railway vehicles in the world.Analysis and assessment of maintenance.Design of technical systems for maintenance.Management of spare parts.Technology in railway vehicles maintenance.Diagnosis of railway vehicles.Maintenance management.The organization of railway repair workshops.Depots.Warehouses.Information and expert systems in the maintenance of rail vehicles.

practical teaching

Understanding the examples from the theory of reliability of the system.Application of the railway vehicles.Examples of the material.Methods of determining the distribution of the data set.Setting reliability requirements and measures for their achievement for rail vehicles.Examples of the completed material.Application of computers in determining the reliability and Information and expert systems in the maintenance of railway vehicles.Creating a computer program - Information and expert system in the maintenance of railway vehicles.Visit the workshop for the maintenance of diesel and electric vehicles.Understanding the system of maintenance of rail vehicles.

prerequisite

Nothing

learning resources

It is necessary the use of textbooks, manuals for the project, a handout, computers and the Internet.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 15
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 5
consultations: 5
discussion and workshop: 5
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 5
colloquium, with assessment: 5
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 10
laboratory exercises: 0
calculation tasks: 0
seminar works: 15
project design: 30
final exam: 35
requirements to take the exam (number of points): 35

references

Theory of Traction

ID: MSc-0297
teaching professor: Лучанин Ј. Војкан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: railway mechanical engineering

goals

Knowledge acquiring in designing, production and exploitation of railway vehicle, in designing of rail tracks as well as the organization of railway traffic.
Introducing students with:
- The Forces acting on railway vehicle,
- Calculation methods for traction, resistance and braking force and the velocity, using modern computer tools,
- The methods for determination of optimal movement conditions of railway vehicles,
- Ways of solving practical problems related to the movement of railway vehicles and rail tracks configuration.

learning outcomes

Understanding and ability to apply knowledge acquired in:
- Calculation of traction, resistance and braking forces and the velocity, using compatible computer software,
- Defining Task and compositional functionality of railway vehicles,
- Using of adequate regulations and standards in the field of traction at railway vehicles.

theoretical teaching

Characteristics of the railway transport, Analysis of the influencing factors on the traction forces, Transmission of traction forces – adhesion as requirement for traction forces, Traction features of high-speed railway vehicles, Traction features of the diesel traction railway vehicles, Basic characteristics of running gear and drive of traction vehicle, Traction features of the electric traction railway vehicles, Train resistance – main and additional resistance, High speeds train resistance, Railway vehicles braking force – characteristics of the braking process, Equations of the train.

practical teaching

Practical learning, Auditory exercises (Introduction to the examples in modern railway transport, Recapitulation of learned material necessary for passing this subject (mechanics, machine elements and electrical engineering), Using of computer tools to solve problems in train traction, Guidance of wheel set in track, The relative velocity of wheel set in relation to the rail, Forces at the wheel set edge point and the contact point of the wheel-rail , Basic characteristics of traction features, adhesion as requirements for traction forces , Basic characteristics of diesel and electric traction railway vehicles, The resistance forces in motion the train, Task (Determination of traction characteristics of the diesel traction vehicles with mechanical and hydraulic power transmission, Determination of traction characteristics of the diesel traction vehicles with electric power transmission, Determination of traction characteristics of the electric traction vehicle, Analytical determination of the resistance force when moving train, Solving differential equations of train), Discussions and workshops.

prerequisite

Nothing

learning resources

Literature that is available in the Faculty Bookstore and Library; Handouts available on lectures; Internet resources (KOBSON).

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 9
laboratory exercises: 0
calculation tasks: 11
seminar works: 0
project design: 0
consultations: 5
discussion and workshop: 5
research: 0

knowledge checks

check and assessment of calculation tasks: 5
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 5
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 20
laboratory exercises: 0
calculation tasks: 30
seminar works: 5
project design: 0
final exam: 35
requirements to take the exam (number of points): 35

references

Lucanin, V., Theory of Traction, Faculty of Mechanical Engineering, Belgrade, 1996.
Andreas Steimel, Electric Traction - Motive Power and Energy Supply, Oldenbourg Industrieverlag Munich, 2008.

Urban and special rail vehicles

ID: MSc-0239
teaching professor: Симић Ж. Горан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: railway mechanical engineering

goals

1. Understanding the specifics of urban rail vehicles.
2. Understanding the various types of special rail vehicles.
3. Qualification for the application of acquired knowledge in the design, development, repair and maintenance of urban rail vehicles and special vehicles

learning outcomes

After completion of the course the student should be able to:
1. Explain the functional and design specificity of various types of urban rail vehicles.
2. Explain the tasks and functionality of various types of special rail vehicles.
3. Explain the specific technologies and technical requirements in combined transport.
4. Apply appropriate regulations and standards in the design and maintenance of urban rail vehicles and special rail vehicles.

theoretical teaching

Forms of urban and suburban transport: trams, light-rail, metro, regional rail. Basic transport unit, the composition of the train/units. Specific requirements dictated by the service conditions: design loads, accelerations, braking, track geometry, the height of the platform. Low-floor designs. Doors, stairs, entrances. Bi-level vehicles. Articulated vehicles. Automatic couplers. Measures for protecting structures and passengers in a crash scenario. Specifics of the running gear and suspension systems for low-floor vehicles and for articulated vehicles. Running gear with pneumatics. Systems with independent wheels: radial steering, the problems of independent drive and braking. Monorail rail systems. Magnetic levitated vehicles. Maintenance of urban rail vehicles: the requirements, the basic management of maintenance, equipment and depots. Combined transport: wagons for transport of containers, swapping bodies and trailers. Gauge problems. Modular cargo compositions. Special wagons.

practical teaching

Geometry of the basic transport unit. Relationship vehicle-platform. Examples of the running gear of urban rail vehicles. Specifics of running through curves with small radius. Design examples of the unconventional rail systems. Division and classification of the transport units for combined transport: pallets, containers, swap bodies. Urban rail vehicles. The determination of the gauge code for semi-trailers in combined transport by rail. Analysis of the design parameters of the wagons for the combined transport. Dimensioning requirements of the tanks by RID regulations. Valve system variants of the tanks for the transportation of the dangerous goods. Design concepts of the magnetic levitating vehicles.

prerequisite

learning resources

G. Simic, Urban and special railway vehicles, hand-out

UIC and RID regulations from the subject field.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 12
laboratory exercises: 0
calculation tasks: 4
seminar works: 3
project design: 0
consultations: 6
discussion and workshop: 5
research: 0

knowledge checks

check and assessment of calculation tasks: 4
check and assessment of lab reports: 0
check and assessment of seminar works: 2
check and assessment of projects: 0
colloquium, with assessment: 4
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 50
laboratory exercises: 0
calculation tasks: 10
seminar works: 10
project design: 0
final exam: 30
requirements to take the exam (number of points): 40

references

strength of structures

Finite element method - FEM
Mechanics of Composite Materials
Strength of constructions and Finite element method

Finite element method - FEM

ID: MSc-0343
teaching professor: Манески Ђ. Ташко
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: seminar works
parent department: strength of structures

goals

Mastering of the Finite Element Method and an active work on the computer. Modeling and calculation of complex structures and problems. Determination of displacements and stresses. Finding the real structure behavior in its operation. Reliable prediction of structural response and determination the cause of bad behavior, yielding and damage of structure. Static, thermal and dynamic analysis.

learning outcomes

The course provides skills to acquisition modeling and design of structures using computers and Finite Element Method. This allows solving the real problems of structural strength in its service life. Mastering the course will enable the application on different areas and active work on the computer using finite element method.

theoretical teaching

Introduction. Finite element modeling of the geometry of the supporting structures. The theory of elasticity. Finite element method. Line primitives and finite elements. Surface primitives and finite elements. Volume primitives and finite elements. Defining characteristics of the elements. Static and thermal analysis. Dynamic analysis. Analysis of the calculation of structure. Computer modeling and calculation of real problems. Load distribution in the structure. Diagnosis of the strength of structure behaviour. Elements of structure optimization.

practical teaching

Working with Programe package KOMIPS. The tasks from line primitives. The tasks of surface primitives. The tasks of volume primitives. Principles of computer modeling and generation of structure geometry. Adding primitives to generate finite element meshes. Computer modeling of supports and loads. Exercise of collecting primitives and generating network elements. Exercise of defining the characteristics of elements, supports and loads. Examples of static and thermal calculation. Examples of dynamic calculation. Diagnostics of structural behavior. Seminar papers from modeling, calculations, load distribution on the structure, analysis of structure calculation, defining elements of structure optimization.

prerequisite

The condition is defined by the curriculum program of the study.

learning resources

1. T. Maneski, Computer modeling and calculation of structures, Faculty of Mechanical Engineering, 1988 - KPN
2. T. Maneski, V.Milošević-Mitic, D. Oštrić, The statement of structural strength, Faculty of Mechanical Engineering, Belgrade, 2000 - KPN
3. T. Maneski, Resolved problems of structural strength, faculty of Mechanical Engineering,

Belgrade, 2000 - KPN
4. KOMIPS - a software package for the calculation of structures - ICT - IAS

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 0
laboratory exercises: 0
calculation tasks: 10
seminar works: 20
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 2
check and assessment of lab reports: 0
check and assessment of seminar works: 8
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 25
laboratory exercises: 0
calculation tasks: 10
seminar works: 25
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

Mechanics of Composite Materials

ID: MSc-0721
teaching professor: Балаћ М. Игор
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: strength of structures

goals

Main objective of the course is to teach students the fundamental principles of the mechanics of composite materials. This theory is further applied to design and analyze unidirectional and multidirectional fiber composite laminates. Within the course the basic issues associated with the design of composite materials will be studied as well. A special attention will be devoted to the practical stress and strain analysis of mechanical components made out of composite materials. Issues connected to the characterization of mechanical properties of composite materials will be tackled as well.

learning outcomes

1. Within the course students will learn various methods of the assessment of elastic constants entering into constitutive equations which describe mechanical behavior of composite materials. Problems of determination of macro behavior of composite materials starting from known properties of components entering into it will be tackled as well. The course will cover also the study of different failure criteria for various types of composite materials.
2. Students will learn how to perform stress – strain analysis of laminate composite materials.
3. The course will devote some attention to the influence of the environmental conditions (e.g. temperature and humidity) to the variation of mechanical properties of composite materials. This will be studied with a special focus on unidirectional and multidirectional composite laminates.
4. By completing this course students will become familiar with basic concepts of mechanics of composite materials. A special attention will be devoted to the practical procedures of stress analysis of mechanical components made out of composite materials, with numerical implementation of the most frequently used techniques.

theoretical teaching

1. Introduction to composite materials: Basic concepts. Classification, main characteristics and the most frequent applications of composite materials in modern engineering.
2. Macro mechanical elastic behavior of unidirectional lamina composites. The Hooke's Law for a two dimensional lamina. Determining stiffness of parallel arrays of fibers in matrix. Rules of mixture. Off-axis properties of a lamina.
3. Determining strength of unidirectional lamina. Analysis of failure criteria. Diverse failure criteria and their applications.
4. Macro mechanical elastic behavior of multidirectional composite laminates. Stress and strain analysis of single lamina, and of the entire composite material. General laminate plate theory. Studding of coupling effects – coupled flexure and torsion.
5. Stress – strain and failure analysis of multidirectional composite materials. Strength of lamina under tension and shear. Inter-laminar stresses. Laminate strength analysis. First ply failure.

practical teaching

1. Analytical examples of the assessment of macro mechanical properties of the composite

materials.
2. Examples of the Hooke’s law theory applied to the two dimensional unidirectional laminates. Determining of the stiffness matrix for the composite material.
3. Numerical exercises of stress strain analysis of laminate composites. Examples of determination of local and global values for stress and strain.
4. Numerical examples of determination of the ultimate strength using diverse failure criteria. Practical applications of failure theory to the ultimate strength calculations of mechanical components made out of composite materials.
5. Examples of numerical implementations of diverse modeling techniques of composite materials into the available codes. Comparison of numerical and analytical predictions of composite material component behavior.

prerequisite

Taken exams:
Strength of materials 1
Strength of materials 2

learning resources

The whole course material is well covered by hand-outs written by the lecturers of the course. Every attendee of the course will be provided his/hers own copy of the hand-outs. Apart of this, all the below mentioned books can be borrowed from the lecturers during the course or ordered on some relevant websites.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 40

active teaching (practical)

auditory exercises: 0
laboratory exercises: 0
calculation tasks: 10
seminar works: 0
project design: 15
consultations: 5
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 2
colloquium, with assessment: 0
test, with assessment: 2
final exam: 1

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 50
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 20
final exam: 30
requirements to take the exam (number of points): 40

references

"Mechanics of composite materials", Autar K. Kaw
"Mechanics and analysis of composite materials", Valery Vasiliev and Evgeny Morozov
"Mechanics of Elastic Composites", Nicolaie Dan Cristescu, Eduard-Marius Craciun and Eugen Soós
"Mechanics of Composite Materials with MATLAB" George Z. Voyiadjis and Peter I. Kattan

Strength of constructions and Finite element method

ID: MSc-0397
teaching professor: Манески Ђ. Ташко
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: strength of structures

goals

The aim of this course is to introduce students with: 1) the problem of torsion of structural elements of arbitrary cross-sections, thin-walled elements of open and closed sections, and the strain of thin plate, 2) the finite element method, its application and active work on the computer, modeling and calculation of complex structures and problems, determination the actual displacements and stresses, determination of causes of bad behavior, dynamic calculation.

learning outcomes

Student has the following general and subject-specific skills:
Mastering of methods and introducing to the appropriate discipline. Acquires the ability to model and design the structures using analytical and computer approach (FEM). This allows solving real complex problems for the structure in operation. Learning to solve particular problems using scientific methods and procedures and to link knowledge from different fields.

theoretical teaching

Introduction. Torsion of an arbitrary cross-section. Complex, rectangular, thin-section. The theory of thin-walled beams. Unconstrained and constrained torsion. Thin-walled beams of open cross-sections. Sectoral geometric characteristics. Shear center. Bimoments. Stresses and strains in the unconstrained and constrained torsion. Differential equation of angle of twist. Thin-walled beams of closed sections (unicellular, multicellular). The theory of plates. Strain in the middle plane of the plate and perpendicular to it. Thin rectangular plates. The criteria of stability of elastic structures. Complex structures.
Finite element modeling and geometry of the supporting structure. The theory of elasticity. Line primitives and finite elements. Surface primitives and final element. Volume primitives and finite elements. Defining characteristics of the elements. Static, thermal, dynamic analysis. Analysis of the calculation of the structure. Computer modeling and calculation of real problems. Load distribution in the structure. Diagnosis of structure behavior. Elements of structure optimization.

practical teaching

Calculation of higher order geometric characteristics. Determination of stress and strain for the problems and loads discussed in theoretical teaching.
Working with program KOMIPS. The tasks of line, surface and volume primitives. Principles of computer modeling and generation of structure geometry. Adding primitives to generate finite element meshes. Computer modeling of supports and loads. Exercises: addition of primitives, generation of element networks, defining element characteristics, supports, the load of the model. Examples of static, thermal, dynamic calculation. Diagnostics of structural behavior. Semester papers from modeling, analysis of calculation, defining elements of the structure optimization.

prerequisite

No conditions.

learning resources

1.Hendauts
2.T. Maneski, Computer modeling and calculation of structures, Faculty of Mechanical Engineering, Belgrade, 1988
3.T. Maneski, V.Milošević-Mitic, D. Oštrić, The statements of structural strength, Faculty of Mechanical Engineering, Belgrade, 2000
4. KOMIPS - a software package for calculation

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 20

active teaching (practical)

auditory exercises: 20
laboratory exercises: 0
calculation tasks: 5
seminar works: 10
project design: 0
consultations: 2
discussion and workshop: 3
research: 0

knowledge checks

check and assessment of calculation tasks: 2
check and assessment of lab reports: 0
check and assessment of seminar works: 2
check and assessment of projects: 0
colloquium, with assessment: 3
test, with assessment: 3
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 25
laboratory exercises: 0
calculation tasks: 10
seminar works: 25
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

theory of machanisms and machines

Engineering Condition Monitoring
Food Processing Engineering Practice(M.Sc.)
Food Processing Machines
Mechanism and Handling Design in Food Industry
MECHANISMS AND MANIPULATORS DESIGN
Mechatronics
Packaging Machines
Product Aestetics

Engineering Condition Monitoring

ID: MSc-0241
teaching professor: Вег Ђ. Александар
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: theory of machanisms and machines

goals

Students are to acquire necessary knowledge to trouble-shoot the machinery, reveal main cause of malfunction and prescribe remedial action. Introduction of equipment and devices for engineering diagnosis and skills development for applying them.

learning outcomes

In this course students prepare to accumulate engineering knowledge and skill to approach an object, use the technical documentation to understand system operation, apply appropriate methods of check out, collect relevant data, compare the the results with ISO proposed norms, make a decision and specify the list of remedial action.

theoretical teaching

Lectures: Description of common objects of diagnosis. Typical machinery composition. Subassemblies. Machinery outlines. Different diagnostic models, monitoring priorities and optimization. Diagnosis of: distributing networks for propelants, compressed air, gases, steam, lubricants, etc. Site measurements. Description and classification of different kind of measurements. Diagnostic algorithms and machinery structurizing. Selection of diagnostic parameters. Diagnostic devices. Functions and accessories. Schedule of inspection. Critical machine operating range. Preliminary measurements. Troubleshooting. Reporting. Overhaul and rehabilitaion program definition. ISO verification. Run out check up. NDT inspection. Lubricants inspection.

practical teaching

Exercises, Lab work: Typical machinery - generators, blowers, pumps, compressors, turbines, transportation lines. Site measurements: temperature, pressure, fluid flow, velocity, position, acceleration, displacement. Site diagnosis: troubleshooting, rehabilitation list. Geometry check out: shape, position and dimensional tolerances. NDT inspection: magnetic particles, chemical agents, ultrasound. Vibrodiagnosis: spectral analysis, peak detection, phase lag measurement. Technical liquids and gases analysis. Proactive strategy of maintenance.

prerequisite

No prerequisites

learning resources

A. Veg, G. Sinikovic, Manuscript "Fundamentals of technical diagnosis"
A.Veg, G.Sinikovic, Handbook of vibrodiagnosis

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 0
laboratory exercises: 24
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 6
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 8
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 2
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 20
laboratory exercises: 45
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

Food Processing Engineering Practice(M.Sc.)

ID: MSc-0236
teaching professor: Стоименов Д. Миодраг
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 1
final exam: seminar works
parent department: theory of machanisms and machines

goals

1. Gaining practical knowledge of food processes and machines.
2. Introduction to machine materials needed for applications in the manufacture of food machinery.
3. Developing creative skills of students in the design of food equipment, machines and systems analysis and design of food exploitation characteristics of machines and plants.

learning outcomes

Successful completion of the study program the student acquires the ability to:
1. Analysis of existing solutions and their effects
2. adoption of knowledge in practice
3. application of knowledge in practice

theoretical teaching

Introduction to the subject. Specifics of the food industry. Basic technological operations related to the production of food products. Plants for the production of food products. Specific features, characteristics and design of machines for the production of food products. Manufacture of food products. Production of flour, sugar, oil and so on. Machines used in the manufacture of food products. Fruit, vegetables, milk and meat. Machinery for processing of fruits, vegetables, milk and meat. Manufacture of bakery and confectionery products. Bakery and confectionery machines and lines.

practical teaching

The first seminar and other seminars. Understanding the production process in work organizations, engaged in manufacturing of food products covered by the lectures. Tour companies involved in the design and construction of producing equipment for the production of food products. Consultation: Review completed active teaching and student questions.

prerequisite

There are no additional requirements for attending a somersault Professional Practice (MSc) Mechanical Engineering Food

learning resources

To cope with cases it is necessary to use Ineternet resources at their disposal prospetktnog materials producers and users of food processing equipment and video

number of hours

total number of hours: 46

active teaching (theoretical)

lectures: 18

active teaching (practical)

auditory exercises: 8
laboratory exercises: 0
calculation tasks: 0
seminar works: 10
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 6
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 0
final exam: 4

assessment of knowledge (maximum number of points - 100)

feedback during course study: 20
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 50
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

Food Processing Machines

ID: MSc-0235
teaching professor: Петровић В. Драган
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: oral
parent department: theory of machanisms and machines

goals

1. Introduction to the basic concepts necessary for understanding the material from this field.
2. Acquiring skills in preparing contemporary construction programs for designing and performance analysis of food processing equipment and plant.
3. Developing students creative abilities for designing food processing equipment, machines and systems.

learning outcomes

1. Analysis of existing problems and their effects
2. Adopting of practical knowledge
3. Practical application of knowledge
4. Introduction and understanding the problematic of food processing machines
5. Resolving concrete problems
6. Connecting knowledge from different fields and their application
7. Tracking and applying innovations in the field.

theoretical teaching

About food processing goods in general and their classification, analyzing basic technological requirements and methods of their realization, machines for processing grains, constructive characteristics and overview of different types of mills as characteristic machines in the field of grain processing, machines in the confectionary industry, overview of the characteristic types of machines for other types of confectionary products, their operational principles and technical characteristics, transportation systems in the confectionary industry, linking individual machines into a technological aggregate for producing the correct confectionary product, automatic lines for producing hard cookies and crackers, typical machines for preparing dough, processing dough and receiving the completed dough shapes, machines for processing fruit and vegetables, machines for processing milk, machines for processing meat

practical teaching

Auditory exercises which include introduction to the basic technical and technological characteristic of typical representatives of food processing machines for grains processing (mills and screens), machines in the baking industry (mixers, separators, fermentation chambers, molders, cutters), machines in the confectionary industry (laminating machines, smoothing, shaping, cutting), machines for processing fruit and vegetables, machines for processing milk and machines for processing meat. Project development which includes defining the project task, necessary calculation and compilation of joint documentation or completed machines.

prerequisite

There are no special requirements for attending Food Processing Machines

learning resources

D. Petrović, R. Andrejević: Food Processing machines, Notes in preparation. For successful mastering of the subject usage of instructions of project development are necessary, handouts, internet resources and video records

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 8
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 20
consultations: 2
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 6
colloquium, with assessment: 4
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 20
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 40
final exam: 30
requirements to take the exam (number of points): 44

references

Mechanism and Handling Design in Food Industry

ID: MSc-0607
teaching professor: Миладиновић Д. Љубомир
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: theory of machanisms and machines

goals

The students то master the skills of designing and constructing the cam and Maltese mechanism. To acquire the ability to analyze them in the machines and devices used in the food industry. To become familiar with the types and working methods of handling systems, as well as the design possibilities of these structures to obtain simple functions.

learning outcomes

The student has mastered the procedures for the construction of mechanisms that are mainly used in machinery and equipment in the food industry as well as to connect the work of individual machines in production lines. The student is familiar with the principles of a Working Model and thus can easily master other software package for modeling and generating mechanisms.

theoretical teaching

A brief review of the kinematic pairs and planar mechanisms; equivalent mechanisms. Cam mechanism, cam plate: translational and rotating; translational and rotating lifter - rounded, with rollers or disc; law of motion, velocity, acceleration, force, synthesis of cam plate. Maltese mechanisms, mechanisms with a toothed wheel and jumper; law of motion, velocity, acceleration, force, the mechanism synthesis . Spatial mechanism; mechanism structure , closed and open kinematic chains, mechanisms with a number of independent drives. Handling system with kinematic pairs of 5-class, a three-member spatial kinematic chains with independent drives; handling systems of type: TTT, TRT, TRR, and RRR RRT and servicing space. Creating a part of a software program for the optimal synthesis of mechanisms in MATLAB for special types of orbits of plane mechanisms. Drive synthesis for spatial handling systems; creating these types of manipulators in the Working Model; defining the desired motion path of the workpiece: 1-with an expression, 2-with a series of oriented positions, reading the law of internal coordinates of a handling system; defining a drive for a handling system.

practical teaching

Equivalent mechanisms; replacing the higher kinematic pair with a kinematic chain with a lower kinematic pairs. Design of a cam plate; generation of diagrams: time, speed and acceleration; use of the ACAD program in the synthesis of cam mechanisms. Design of a Maltese mechanism; selection of a Maltese mechanism; motion, velocity and acceleration diagrams; defining parameters for a toothed wheel and jumper. Design of of a mechanism with a specific path; mechanism synthesis using MATLAB and design in Working Model for a specified path. Design of TTT, TRT, ... handlin systems using Working Model; defining independent drives, determination of forces in kinematic pairs; defining driving forces and moments. Handling System of type TTT, TRT, ...design, according to the given displacement of the workpiece (or a series of oriented positions).

prerequisite

To attend classes of the subject Mechanism and Handling Design in Food Industry, no condition is necessary.

learning resources

A. Sekulić: Mechanism Design
B. Gligorić: Mechanisms
Working Model Software Package

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 11
laboratory exercises: 19
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 10
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 35
laboratory exercises: 15
calculation tasks: 0
seminar works: 0
project design: 20
final exam: 30
requirements to take the exam (number of points): 35

references

MECHANISMS AND MANIPULATORS DESIGN

ID: MSc-0244
teaching professor: Ђорђевић Р. Стеван
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: theory of machanisms and machines

goals

Students master skills of designing and constructing the Maltese cam mechanism. To acquire them in analysis ability of machines and devices used in food industry. To become familiar with the types and manipulators operational principles, as well as the capabilities of the simple structure of the same functions.

learning outcomes

Student has mastered the procedures for the construction of mechanisms that are mainly used in machinery and equipment for the food industry and to link the work of individual machines in production lines. Student is familiar with the principles of a working model and thus can be easily mastered and some other package for modeling and generating mechanisms of movement in practice.

theoretical teaching

A brief review of kinematical pairs and planar mechanisms; equivalent mechanisms; Cam mechanism, cam panel: translational and rotating; translational and rotary windows: the curvy, clamp or disc; law of motion, speed, acceleration, force, synthesis of cam plates. Maltese mechanisms, mechanisms with toothed wheel and grasshoppers; law of motion, speed, acceleration, force, synthesis mechanism; Spatial mechanisms, structure mechanisms, closed and open kinematical chains, mechanisms with a number of independent facilities. Manipulators with kinematical pairs of the 5th-class, three-spatial kinematical chains with independent facilities, the manipulators of type: TTT, TRT, TRR, RRT and RRR and servicing space; Creation of programs for optimal synthesis of mechanisms in MATLAB for special forms of the path of plane mechanisms. Synthesis of plant spatial manipulators, creating these types of manipulators in the Working Model, defining the desired law of movement of the work piece: 1-expression, a series of 2-oriented position, reading the law changes the internal coordinates of manipulators; defining drive manipulators.

practical teaching

Equivalent mechanisms; construction cam plate; structure diagrams: time, speed and acceleration, use of the ACAD program in the synthesis of cam mechanisms. Maltese construction machinery; Maltese selection mechanism; diagrams: motion, velocity and acceleration; defining parameters tooth point and grasshoppers; Structural mechanism of the characteristic path; mechanism synthesis in MATLAB and structures in the working model in the specified form working part of the path. Construction of manipulators TTT, TRT, Working Modeling, defining independent drive, determination of forces in kinematical pairs, defining the operational forces and moments; Construction of manipulators TTT, TRT, ... law in a given movement of the work piece (features or sequence-oriented position).

prerequisite

Desirable: passing an examination of Designing mechanisms and Basic unit operations in food mechanical engineering.

learning resources

A. Sekulic: DESIGNING MECHANISMS;
B. Gligoric: MECHANISMS;
S. Djordjevic: Handout;
WORKING MODEL – Software application
MATLAB - Software application

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 12
laboratory exercises: 18
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 10
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 35
laboratory exercises: 15
calculation tasks: 0
seminar works: 0
project design: 20
final exam: 30
requirements to take the exam (number of points): 35

references

Z. Zivkovic: Mechanisms and Machine Theory;
Ju. Kozirev: Industrial robots;

Mechatronics

ID: MSc-0201
teaching professor: Вег Ђ. Александар
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: theory of machanisms and machines

goals

Quantum of knowledge acquired for a competent analysis of the mechatronical composition, design of applied mechanism, selection of appropriate control unit and creation of flow-chart diagram. Engineering skill development to synthesize an optimal mechatronical solution to fulfil specified technical requirements.

learning outcomes

Achievment of the engineering experise in a true analysis of mechanisms, sensors, actuators and PLCs as a main componenets of a mechatronical system. Based on a well studied reverse engineering (analysis), a skillful approach to the direct design (synthesis) of an original mechatronical concept.

theoretical teaching

Theoretical conciderations; Introduction of Mechatronics discipline; Intelligent mechanisms and assemblies, and their applications; Design in Mechatronics, fundamentals; Theory of Machines and Mechanisms;Mechanisms classification; Measurements in Mechatronics #1, Analog sensors and Digital detectors; Measurements in Mechatronics #2; Opto sensors; Actuating units in Mechatronics; Linear and rotary actuators; Hybrid actuators, hydro, pneumatic, electric items; Analog and digital modules; Logic circuits and applications; Binary detection (0, 1); PLCs and other control units; Flow charts; Programming tools; IN/OUT ports programming

practical teaching

Practical Lab-work: Typical Mechatronical units; Turbo charger with an adaptable configuration; Decomposition into parts and sub-assemblies; Part structural and functional analysis; Sensorics and Signals; Mechanisms elementary; Diverse mechanisms for a distinctive paths and motion profile; Range of Sensors #1; Range of Sensors #2; Measurements performed with a PC connected to NI modules and supported by LabView environment; Outcome of measurements, numerical and graphical presentation; Actuators; Electric motors; Frequency inverters; Operational amplifiers; PC development platform; PIC development platform;

prerequisite

No prerequisites

learning resources

Manuscript: 'Mechatronics fundamentals', in fragments, A.Veg, E.Veg
Functional models: planar and spatial mechanisms
Sensors: accelerometers, thermometers, proximity probes, optical encoders
Proto boards
Development kit: ELVIS Ni
Development SW: LabView Ni

Dvelopment kit: DS PIC
Actuators: el. motors, freq. inverters, pneumatic cylinders, valves

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 0
laboratory exercises: 25
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 5
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 7
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 3
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 25
laboratory exercises: 40
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

Packaging Machines

ID: MSc-0231
teaching professor: Миладиновић Д. Љубомир
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: theory of machanisms and machines

goals

Getting started with the machines that achieve these technological solutions. Acquiring the necessary knowledge in the field of thermal processes that are necessary for certain types of packages. Introduction to various techniques for normal and sterile package closing.

learning outcomes

This course gives the knowledge necessary for the maintenance of various packaging machinery that can be found in food and other industries. It also gives the necessary knowledge to the investors that order and purchase packaging machines. Besides this, students get all the specific technological, process and design knowledge for projecting and design of packaging machines.

theoretical teaching

Worm dozers and scales for packaging machines - dependence of the worm shape and the structure and quality of dozed material will be defined. Special attention will be paid to scales. Packaging lines - a combination of blowing, filling and sealing machines. Packaging machines with extrusion tubes - specific packaging line in which the container is made of extruded plastic tubes. Packaging machines with a heat extraction vessel - the specific packaging line in which the vessel is made by shallow or deep extraction of plastic foil.

practical teaching

Packages obtained by injection of pellets. Packages obtained by extraction of plastic foil. Packages obtained by tubes extruding. Packaging lines - 2: A combination of machines for blowing, filling and sealing. Packaging lines - 1: A combination machine for blowing, filling and sealing, pneumatic and hydraulic schemes. Dozers, palletizers, sealing machines, wrapping machines for stretch and shrink film. Classification of packaging machines. Industrial packaging. Multifunctional packing machines - machines for filling and sealing. Gravimetric machines - worm dozers and scales in packaging machines. Dependence of the worm shape and the structure and quality of dozed material will be defined. Scales will be treated in particular.
Machines for grouping and ungrouping aggregate packages.

prerequisite

To attend classes of the subject Packaging machines, no condition is necessary.

learning resources

To successfully master this subject, it is necessary to use a textbook that is in preparation, instructions for preparation of seminar papers, handouts, Internet resources.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 0
laboratory exercises: 18
calculation tasks: 0
seminar works: 5
project design: 0
consultations: 7
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 4
check and assessment of seminar works: 3
check and assessment of projects: 0
colloquium, with assessment: 3
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 20
laboratory exercises: 25
calculation tasks: 0
seminar works: 20
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

Lj. Miladinovic, M. Stoimenov, A. Veg, "Packaging Machines", monography
Geoffrey Boothroyd, Assembly Automation and Product Design, Taylor & Francis, 2005.
Andreas Gäotzendorfer, Vibrated granular matter: transport, fluidization, and patterns, Universität Bayreuth, 2007.

Product Aestetics

ID: MSc-0270
teaching professor: Попконстатиновић Д. Бранислав
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: theory of machanisms and machines

goals

Introduce students to the standards and laws of aesthetics in the process of product design, recognizing the subjective and objective factors of establishing the aesthetic judgement; introduction to the cultural and historical aspects and schools of aesthetics; treatment of aesthetic elements and principles, the study of geometric harmony laws, the use of traditional and modern means of creating aesthetic properties; introduction to the features of modern graphical signs and aesthetic properties of packaging and advertising.

learning outcomes

Student has gained the ability of aesthetic evaluation and the formation of aesthetic judgement, through theoretical and practical courses, student is trained to creatively use both abstract elements and principles of aesthetics and practicality (classical and modern) means of creating aesthetic characteristics of the product;

theoretical teaching

Aesthetics definition and etymology of the name; concept, factors and aesthetic significance of the judgement of sentiment and aesthetic standards; explanation of the relativity of aesthetic judgement through a short presentation on the history and origin of aesthetics; aesthetics as a factor of visual communications, detailed analysis of the aesthetic elements of Product design, processing and analysis of basic aesthetic principles of Products design; processing of geometric principles as essential factors of aesthetics of visual communication; concept of the composition harmony, methods of creating and presenting aesthetic properties (classical and modern); sketching and drawing the basic principles of oblique projections, orthogonal axonometry, central projections and prospective, Principles of computer modeling using the appropriate forms CAD software; the concept of modern graphical signs and symbols; the role of graphic symbols in the context of contemporary visual communications; aesthetics of signs, symbols and meanings; aesthetic properties of product packaging, advertising and product presentations;

practical teaching

Independent analysis, creation and presentation of examples on aesthetic universal attitude and the basic principles of induction of aesthetic value, aesthetic evaluation, discussion on cultural and historical aspects of aesthetics, training the use of aesthetic elements and principles; constructive analysis of classical geometrical laws of aesthetics; exercises using classical and contemporary means of creating and presenting the aesthetic properties of products; exercise in creating graphical symbols and signs with an emphasis on aesthetic visual meaning;

prerequisite

Required: Passed courses Constructive Geometry and Engineering Graphics. Desirable: Passed courses Machine elements 1 and 2

learning resources

Script: The aesthetics of the product, by Branislav Popkonstantinović; need additional materials (handouts, exercises, essay titles, etc..) are given at the web site or reproduced on paper. Large-scale electronic materials can be made available to students in direct contact. Teaching is done by combining video images and tables.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 7
laboratory exercises: 6
calculation tasks: 7
seminar works: 7
project design: 0
consultations: 3
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 2
check and assessment of seminar works: 2
check and assessment of projects: 0
colloquium, with assessment: 6
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 40
laboratory exercises: 10
calculation tasks: 10
seminar works: 10
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

thermal power engineering

Computer simulations of thermalhydraulic processes and CFD

ID: MSc-0153
teaching professor: Стевановић Д. Владимир
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: thermal power engineering

goals

The aim is acquiring knowledge and skills for development and application of analytical and numerical models of thermal-hydraulic processes in energy, thermal and process equipment, as well as application of numerical methods for the simulation and analyses of one-phase and two-phase systems in pipelines and plant equipment, including the methods of Computational Fluid Dynamics - CFD.

learning outcomes

The students are trained to perform computer simulation and analyses of heat transfer and fluid flow processes of one-phase and two-phase gas-liquid systems with and without phase transitions in energy, thermal and process equipment.

theoretical teaching

Modelling of thermal and flow processes with lumped and distributed parameters. Balance equations of mass, momentum and energy and constitutive correlations for interface transfer processes. Explicit and implicit numerical methods for the solving of Cauchy problems with defined initial conditions in cases of the lumped parameter models. The method of characteristics for the solving of hyperbolic system of partial differential equations. The application of the method of control volumes of the SIMPLE type for the solving of elliptic and parabolic multidimensional models with distributed parameters. Numerical grid generation. Graphical presentation of results.

practical teaching

Development of the models with lumped parameters for the pressure dynamics prediction in the pressurized vessels filled with one phase compressible fluid or two-phase mixture of liquid and condensing vapour. Numerical simulation of pressure transients in the pressurizer, in the feedwater tank and the drum of a steam boiler. Development of models with distributed parameters for one-phase and two-phase flows with or without phase transitions. Numerical simulations of pressure and temperature waves propagation in pipeline networks. Computer simulations and analyses of multidimensional two-phase flows in steam generators, evaporators, condensers, heat exchangers, etc.

prerequisite

Passed exams in Fluid Mechanics, Thermodynamics, and Numerical Methods.

learning resources

Course handouts.
Stevanović, V., Thermal-Hydraulics of Steam Generators – Modelling and Numerical Simulation, Monograph, Faculty of Mechanical Engineering, Belgrade, 2006.
Computer equipment.

Software for numerical solving of systems of differential equations of various types.
Software for simulation and analyses of pressure transients in pipeline networks and pressurized vessels.
Software for simulation and analyses of multidimensional two-phase flows.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 15
laboratory exercises: 15
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 5
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 5
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 30
laboratory exercises: 35
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

Versteeg, H.K., Malalasekera, W., An introduction to Computational Fluid Dynamics, Longman Group Ltd., Harlow, 1995.
Wulff, W., Computational methods for multiphase flow, Multiphase Science and Technology, Vol. 5, Begell House, 1990.
Streeter, V.L., Wylie, E.B., Hydraulic Transients, McGraw Hill, New York, 1967.
Tannehill, J.C., Anderson, D.A., Pletcher, R.H., Computational Fluid Mechanics and Heat Transfer, Taylor&Francis, New York, 1997.
Stevanovic, V., Thermal-Hydraulics of Steam Generators – Modelling and Numerical Simulation, University of Belgrade, Faculty of Mechanical Engineering, 2006.

Energy Planning

ID: MSc-0105
teaching professor: Стевановић Д. Владимир
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: thermal power engineering

goals

The aims of the subject are to master the methods for the analyses and planning of the macro energy systems at the level of economy and industry sectors, regions and the country, including analyses and formation of energy balances, prediction of energy flows and the structure of energy consumption, classification of energy carriers and indicators of energy consumption, the relation between the economic growth and energy consumption, the state regulative in the energy sector, the environmental impact of energy consumption etc.

learning outcomes

Students acquire a knowledge and skills related to energy planning by using statistical and econometric methods and by applying the phenomenological models, as well as related to methods for providing the basis for planning procedures, such as analyses and preparation of energy balances, prediction of indicators of energy consumption, etc.

theoretical teaching

Macro energy systems, energy systems of Serbia and the World: energy balance of Serbia, energy flows and structure of energy consumption in Serbia and the World. Classification of energy carriers and indicators of energy consumption. Relation between economic growth and energy consumption. Specific and useful energy consumption. Energy efficiency. Energy audit. Rational energy consumption. Techno-economic methods for energy investment evaluations and measures for rational energy consumption. Renewable energy consumption and new energy sources/technologies. Processes and plants for energy accumulations. Methods for energy systems modelling. Energy planning and policy. Law regulative in energy sector. Environmental impact of energy consumption.

practical teaching

Macro energy systems balancing, prediction of energy, economic and technological indicators of energy consumption, optimization and usage of energy plants for electricity production, planning of energy needs, electricity production costs, optimization of dimensions and operational parameters of energy plants and equipment, measures for rational energy consumption, methods for economic evaluation of energy efficiency measures (the net present value method, the internal rate of return method and the pay back period).

prerequisite

Passed exams in Thermodynamics and one subject within the Module for Thermal Power Engineering.

learning resources

Handouts.
Ristic, M., General energetics, Faculty of Mechanical Engineering, Belgrade, 1981.

Personal computers.
Software for energy planning and economic evaluation of investments.
Internet presentations of International Energy Agency and World Energy Council.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 20
laboratory exercises: 0
calculation tasks: 10
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 10
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 65
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

Kleinpeter, M., Energy Planning and Policy, John Wiley & Sons, New York, 1995.
Chateau, B., Lapillonne, B., Energy Demand: Facts and Trends, Springer-Verlag, New York, 1982.
Eastop, T.D., Croft, D.R., Energy Efficiency, Longman Scientific & Technical, Harlow, 1990.
Gottschalk, C.M., Industrial Energy Conservation, John Wiley & Sons, 1996.
Energy Policy, The International Journal, Elsevier.

Environmental Protection in Thermal Power Engineering

ID: MSc-0355
teaching professor: Савић М. Бранислав
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: thermal power engineering

goals

The aim is acquiring academic knowledge about sources and characteristics of hazardous gases emission and other harmful influences in all phases of thermal power plants exploitation, about the environmental influence of harmful emissions, about possible technical solutions, processes and equipment for the emission reduction, harmful waste storage, as well as about the importance of these activities for economic and social development.

learning outcomes

The students master their knowledge and skills in the field of environmental protection from the harmful emissions from the thermal power plants. Besides being acquainted with the sources of harmful emissions and methods and equipment for their reduction and storage, the students are trained to quantify harmful emissions and to estimate the technical, ecological and economical effects of current methods and measures for environmental protection.

theoretical teaching

The influence of thermal power plants on environment and harmful emissions, maximum allowed emissions, regulatory laws related to harmful emissions, international activities towards environment protection and reduction of green house gases emissions, technologies and plants for emission reductions from thermal power plants, such as dust removal from flue gases, flue gases desulphurization, NOx removal, carbon dioxide capture and storage. The influence of atmospheric conditions on emissions propagation and harmful matters dispersion, storage of solid combustion products, heat load to the environment from thermal power plants, current developments of thermal power plants efficiencies from the standpoint of emissions reductions.

practical teaching

Prediction of the harmful emissions during the operation of the thermal power plants, evaluation of conceptual design of plants for the harmful emissions reduction in accordance with the law regulation, ecological and economical effects of methods for emission reduction, criteria for chimney selection, analyses of wet and dry methods for flue gases desulfurization, analyses of plant accidental conditions on environmental pollution.

prerequisite

Passed exams in Thermodynamics.

learning resources

Course handouts.
Instructions for project preparation.

Savic, B., Pollution of environment by flue gases emitted from chimney to the atmosphere in thermal power plants, Master thesis, Faculty of Mechanical Engineering, Belgrade, 1982.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 10
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 15
consultations: 5
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 5
colloquium, with assessment: 5
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 35
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 30
final exam: 30
requirements to take the exam (number of points): 30

references

Salvato, J.A., Nemerow, N.L., Agardy, F.J., Environmental Enginering, Wiley, 2003.
Woodruf, E.B., Lammers, H.B., Lammers, T.F., Steam Plant Operation, McGraw-Hill, New York, 1998.

Gas Turbines

ID: MSc-0300
teaching professor: Петровић В. Милан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: thermal power engineering

goals

1. The achievement of academic competence in the field of gas turbines and thermal power plant engineering.
2. Mastery of theoretical knowledge about how to transform heat into mechanical work of thermodynamic processes and equipment (gas turbines and gas turbine power plants).
3. The acquisition of practical skills for design and optimization of gas and gas turbine cycle.
4. Mastering the techniques of process modeling.

learning outcomes

1. Academic deep knowledge of the thermodynamic cycle and flows in gas turbines and gas turbine plants
2. The development of critical thinking about energy use, fuel efficiency and environmental preservation
3. The ability of calculate heat balance diagrams and main parameters of the gas turbine power plants.
4. Ability to use computer technology for modeling and calculations

theoretical teaching

Theoretical teaching is carried out through 10 teaching modules:
1. Thermodynamic basis of the gas turbines power plants. The basic thermodynamic cycles.
2. The basic and main thermodynamic parameters of the gas turbine plants.
3. The influence of basic parameters on the performance of the gas turbine plants. The choice of optimal parameters of the gas turbine plants.
4. Energy balance of the gas turbine plants. Improvements the thermodynamic gas turbine plants.
5. More complex cycles of gas turbine plants.
6. Combined gas and steam plant turbine. Gas turbine plants with gasification of coal.
7. The application of gas turbines in the energy and airplane propulsion.
8. The construction of gas turbines. Materials of gas turbines. Selection of temperature at the entrance to the gas turbine. Blade cooling and cooling problems.
9. Combustion chambers - functions and operating principles, performance. Types of combustion chambers. Fuel for gas turbines. Auxiliary equipment of gas turbine plants.
10. Operating characteristics of gas turbines - change mode. Regulation of gas turbines.

practical teaching

Practical training is carried out through:
Auditory exercises:
Basic principles. Historical development. Classification, properties and applications of gas turbines.
The application of gas turbines for the propulsion of vehicles, ships rail.
Instructions for project 1: Calculation of the gas turbine thermal cycle (heat balance diagram) of the gas turbine plants.

Instructions for project 2: Calculation of the combined cycle with gas turbine and steam turbine (CCGT).
Project development:
Calculation of heat balance of the gas turbine power plant.
Calculation heat balance diagram of combined cycle with gas turbine and steam turbine.
Labs:
introduction in principles of operation and design of gas turbines in the Laboratory for steam and gas turbines

prerequisite

Passed exams in Thermodynamics and Fluid mechanics

learning resources

Petrovic, M.: Gas turbines and compressors, script, 2004.
Petrovic, M.: Gas turbines and compressors, introduction for exercises, 2004.
Petrovic, M. scripts and handouts for Gas turbines
Instructions for performing laboratory exercises
Software package for calculating of properties of combustion products

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 10
laboratory exercises: 4
calculation tasks: 0
seminar works: 0
project design: 13
consultations: 0
discussion and workshop: 3
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 1
check and assessment of seminar works: 0
check and assessment of projects: 7
colloquium, with assessment: 0
test, with assessment: 2
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 10
laboratory exercises: 5
calculation tasks: 0

seminar works: 0
project design: 30
final exam: 50
requirements to take the exam (number of points): 25

references

Petrovic, M.: Gas turbines and compressors, script, 2004.
Stojanovic, Thermal Turbomachinery, Gradjevinska knjiga, belgrade, 1967.
Cohen, H., Rogers,G.F.C., Saravanamuttoo, H.I.H.: Gas turbine theory, Logman, 1997.
Traupel,W.: Thermische Turbomaschinen, Springer verlag, Berlin, 1982
Boyce, M.: Gas turbine engineering hadbook, GPB, Boston 2002.

Industrial and District Heating Thermal Power Plants

ID: MSc-0338
teaching professor: Савић М. Бранислав
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: thermal power engineering

goals

The purpose of the course is to provide a knowledge basis in the field of specific application of thermal power plants for the combined production of electric energy and heat within industrial and utility thermal power engineering. In the development of modern thermal power engineering, application of cogeneration is gaining relevance, due to significant primary energy savings. The practice program consists of creating calculation tasks for the cogeneration regimes, based on the implementation of certain gained practical knowledge in the course program.

learning outcomes

The course provides the practical knowledge a graduated mechanical engineer needs in order to work in the field of combined production of energy, which is gaining relevance and stimulus for application worldwide, due to significant primary energy savings. Given that the field of application of cogeneration of energy in the process of planning and design is the most complex area of thermal power engineering, gaining competitive knowledge in the field is of great importance for a thermal power engineer.

theoretical teaching

Development and importance of application of cogeneration of energy worldwide. Thermodynamic effects of cogeneration of energy and energetic advantages of application of cogeneration of energy in comparison to identical separate production at the thermal power plant and heating plant. Types of thermal power plants for cogeneration of energy: steam thermal power plants, gas thermal power plants and combined gas-steam thermal power plants. The factors which influence the choice of thermal power plant for cogeneration of energy. Heat consumption diagrams. Main thermodynamic parameters of cogeneration of energy. Influence of consumer distance on the choice of parameters and primary energy savings in cogeneration. Types of steam turbo-units for cogeneration of energy. Steam thermal power plants for cogeneration of energy. Different control of load and mass flow rate steam turbine characteristic. Cogeneration of energy regime diagrams.

practical teaching

The practical course includes three tasks in the field of application of cogeneration of energy. The first task relates to the regimes with an open and partially open control valve for regulating steam extraction of the condensation turbine, with one regulated steam extraction. The second task relates to the regimes of cogeneration with and without avoiding the steam unit regenerating high-pressure heaters of the condensation turbine with one regulated steam extraction. And the third task relates to the definition of diagrams of heating consumption requirements and diagrams of quality regulation of heating requirements in the surface exchanger of the sub-station of the centralized heating system.

prerequisite

Passed exams in Steam and Gas turbines are desirable.

learning resources

Written extracts from the lectures:
1. Kostyuk, A. Frolov V.: Steam and Gas Turbines, Energoatomizdat, Moscow, 1988.-КСЈ
2. Rižkin, V.: "Тепловие електрические станциј", Energoatomizdat, Moscow, 1987.-КСЈ
3. Stojanović, D.: "Toplotne turbomašine", Građevinska knjiga, Belgrade, 1973. - KDA
4. Savić, B.: "Prilog energetskoj osnovi razvoja i uklapanja kombinovane proizvodnje toplotne i električne energije u elektroenergetski sistem", Faculty of mechanical engineering, Belgrade, 1989. dr. dissertation - KPN

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 6
laboratory exercises: 0
calculation tasks: 20
seminar works: 0
project design: 0
consultations: 4
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 5
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 5
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 30
laboratory exercises: 0
calculation tasks: 25
seminar works: 0
project design: 0
final exam: 35
requirements to take the exam (number of points): 30

references

1. Kostyuk A., Frolov V.: Steam and Gas Turbines, Energoatomizdat, Moscow, 1988.-КСЈ
2. Рижкин, В.: Thermal power plants, Енергоатомиздат, Moscow, 1987.-КСЈ
3. Стојановић, Д.: Steam and gas turbines, Грађевинска књига, Belgrade, 1973.-КДА
4. Савић, Б.: Possibilities of development and fitting cogeneration of heat and electric energy into power system, FME, Belgrade, 1989. doctorate dissertation -КПН

Nuclear Reactors

ID: MSc-0345
teaching professor: Стевановић Д. Владимир
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: thermal power engineering

goals

The aims of the subject are acquiring academic knowledge about processes and equipment for nuclear energy utilization, about neutron processes and fission, principles of nuclear reactors design, reactor core cooling, nuclear fuel characteristics, transport and storage of nuclear waste, nuclear reactors safety, nuclear accidents in Nuclear Power Plants Three Mile Island, Chernobyl and Fukushima, as well as current nuclear reactors developments.

learning outcomes

Students are able to design nuclear reactor core, determine the thermal and neutron characteristics of nuclear fuel, moderator and reactor coolant, define basic elements of nuclear power plant safety and determine basic technical, technological, ecological and economic conditions and boundaries for the application of nuclear energy.

theoretical teaching

Processes and equipment of nuclear energy plants. Characteristics of nuclear fuel, atomic and nuclear processes important for the nuclear reactors operation. design of nuclear reactor material structure and critical dimensions. Diffusion and thermalization of neutrons. Solving of reactor equation. Operating characteristics and safety of nuclear reactors and nuclear power plants. Feedback between nuclear and thermal processes in the nuclear reactor core. Cooling of the nuclear fuel elements, heat transport and boiling crises. Computer codes for thermal-hydraulic simulation and analyses. Overview of nuclear energy in the World and its current development. The roll of the nuclear energy in the energy sustainable development.

practical teaching

The students solve the problems related to nuclear reactors design and analyses of its operation conditions. The numerical experiments are performed with the computer simulations of nuclear reactor processes: calculation of the radioactive chain decay, neutron life cycle and reactor equation solving for various types of nuclear reactors, the model development and computer simulation of the loss-of-feedwater accident in a plant with the pressurized water reactor.

prerequisite

Passed exams in Physics, Thermodynamics, Numerical methods.

learning resources

Course handouts.
Ristic, M., et al. Modelling of transients in nuclear steam supply systems, Faculty of Mechanical Engineering, Belgrade, 1984.
Ristic, M., Nuclear Reactors, Faculty of Mechanical Engineering, Belgrade, 1969.
Computer equipment.

Software for numerical solving systems of differential equations.
Software for the design of nuclear reactor core.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 15
laboratory exercises: 15
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 5
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 5
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 35
laboratory exercises: 30
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

Klimov, A., Nuclear Physics and Nuclear Reactors, Mir Publishers, Moscow, 1981.
Tong, L.S., Design Improvement for Light Water Reactors, Hemisphere, New York, 1988.
Knief, R.A., Nuclear Energy Technology, Hemisphere, 1981.
Foster, A., Wright, R.L., Basic Nuclear Engineering, Allyn and Bacon, Inc., Boston, 1977.

Planning and Exploitation of Thermal Power Plants

ID: MSc-0165
teaching professor: Савић М. Бранислав
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: thermal power engineering

goals

The purpose of this course is to provide necessary knowledge base in the area of planning and design, contracting and acceptance testing, exploitation and maintenance of thermal power plants. The course practice program consists of the creation of a simplified conceptual project of the power plant based on the implementation of certain practical knowledge gained during the course.

learning outcomes

The program provides the practical knowledge a graduated mechanical engineer needs in order to work in the field of thermal power engineering, which enables him to solve certain practical problems more easily and quickly. Such competence includes mastering the procedures of analytic and synthetic consideration of choice of type and sort of thermal power plant in the procedure of planning and design, as well as inclusion into the process of exploitation and maintenance.

theoretical teaching

The main phases of designing thermal power plants. Criteria for choosing the type and location of a thermal power plant. Contents of the conceptual project, along with the investment program. General disposition and composition of a thermal power plant. Guidelines for contracting and provision of thermal power plant equipment. Assume-guarantee and operation testing of a thermal power plant. Behavior of a thermal power plant in operation: starting and stopping regimes. Maintenance and monitoring the thermal power plant in operating conditions: maintenance of the protection and regulation system, monitoring turbine functioning, turbine depositions and their separation, importance of maintaining a quality water regime, condensation plant, regenerating heating system of the main condensate and feed water, turbine sealing system, etc. The importance of application of diagnostics in operating conditions, control of economy and functional operation state of a thermal power plant. Reliability and availability of a thermal power plant.

practical teaching

The content of the course includes the creation of a conceptual design of the thermal power plant: choice of micro-location and general concept of the thermal power plant, choice of disposition of all thermal power plant facilities, analysis of the choice of heating scheme and parameters. Main operating facility: analysis of the choice of heating scheme and parameters, choice of boiler plant, choice of turbo-generator. Completion of a computing task, which consists of creating a computer program intended to calculate the influence of deviation of fresh steam parameters on the economy of a steam unit.

prerequisite

Previously passed exam in Thermal power plants.

learning resources

Written extracts from the lectures.
1. Kostyuk, A. and Frolov V.: Steam and Gas Turbines, Energoatomizdat, Mir Publishers Moscow, 1988.-КСЈ
2. Rižkin, V.: "Тепловие електрические станциј", Energoatomizdat, Moscow, 1987.-КСЈ
3. Stojanović, D.: "Toplotne turbomašine", Građevinska knjiga, Belgrade, 1973. - KDA
4. Vasiljević, N., Savić, B., Stojaković, M.: "Istraživanje optimalnih projektnih i eksploatacionih uslova rada kondenzacijskog dela parnih turbopostrojenja", Faculty of mechanical engineering, Belgrade, 1991. - KPN
5. Schroeder, K: Grosse Dampftkraftwerke, Springer Verlag, Berlin, 1962
6. CEGB: Modern Power Station Practice, Pergamon press, Oxford, 1971

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 6
laboratory exercises: 0
calculation tasks: 4
seminar works: 0
project design: 20
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 3
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 5
colloquium, with assessment: 0
test, with assessment: 2
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 20
laboratory exercises: 0
calculation tasks: 10
seminar works: 0
project design: 30
final exam: 30
requirements to take the exam (number of points): 30

references

1. Kostyuk, A. and Frolov V.: Steam and Gas Turbines, Energoatomizdat, Mir Publishers Moscow, 1988.-KCJ
2. Rižkin, V.: "Thermal power plants", Energoatomizdat, Moscow, 1987.-KCJ
3. Stojanović, D.: "Steam and gas turbines", Građevinska knjiga, Belgrade, 1973. - KDA
4. Vasiljević, N., Savić, B., Stojaković, M.: "Research of optimal design and exploitation working conditions of the cold-end of a steam turbine plant", FME, Belgrade, 1991. - KPN
5. Schroeder, K: Grosse Dampftkraftwerke, Springer Verlag, Berlin, 1962

Steam generators

ID: MSc-0129
teaching professor: Стевановић Д. Владимир
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: thermal power engineering

goals

The aims of the subject are acquiring academic knowledge about processes and equipment for steam generation in thermal power plants, building and mastering skills in scientific and engineering methods for the prediction, analyses and research of thermal-hydraulic processes in steam generators, as well as skills in methods for the design, safety analyses and diagnostics of the operational conditions of the steam generators.

learning outcomes

Mastering the course the students are able to simulate and analyze processes, design equipment and prescribe operational conditions in steam generators by applying the modern scientific and engineering methods for various conditions of exploitation. Also, the application of acquired knowledge and skills in every stage of design, manufacture and exploitation provide the safe, reliable and economically and energetically efficient operation of steam generators.

theoretical teaching

Design of steam generators; thermal-hydraulic parameters of vapour and liquid two-phase flow: static, flow and thermodynamic quality, vapour void fraction, two-phase mixture density, superficial velocity, two-phase flow mass flux, slip factor, drift velocity, etc.; heat transfer mechanisms in convective heating, boiling and superheating of working fluids or heat carriers; the critical heat flux; pressure change in two-phase flow; modelling of thermal-hydraulic processes in steam generators: the homogeneous model, the slip model, the two-fluid and multi-fluid models of two-phase mixture flows; numerical methods for solving the thermal-hydraulic models of two-phase flow; computer simulations of operational conditions of steam generators; pressure waves propagation and dynamic loads of pipelines in transient conditions; the chocked flow; the condensation induced water hammer; two-phase flow instabilities; steam separation.

practical teaching

Prediction of two-phase flow parameters for various geometry and boundary conditions. Calculation of two-phase flow pressure drop. Calculation of mass, momentum and energy balances in evaporating channel. Prediction of boiling and dry-out boundaries in evaporating channels. Calculation of thermal-hydraulic parameters in circulation loops in steam generators. A development of one-phase and two-phase flow models for the simulation and analyses of two-phase flow in evaporating channels: mass, momentum and energy balance equations, closure laws for interfacial transport processes. Numerical methods fro two-phase flow models solving. Computer simulations of circulation loops in steam generators at full and partial loads. Modelling and computer simulation of pressure transients in pressurizers filled with vapour and liquid phases.

prerequisite

Passed exams in Thermodynamics, Fluid mechanics and Numerical methods.

learning resources

Subject handouts.
Stevanović, V., Thermal-Hydraulics of Steam Generators – Modelling and Numerical Simulation, Monograph, Faculty of Mechanical Engineering, Belgrade, 2006, ISBN 86-7083-569-X.
Personal computers.
Software for the solving of systems of differential equations.
Software for the simulation and analyses of pressure transients in pipeline networks and pressurizers.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 5
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 25
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 5
colloquium, with assessment: 5
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 35
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 30
final exam: 30
requirements to take the exam (number of points): 30

references

Ishigai, S., Steam Power Engineering - Thermal and Hydraulic Design Principles, Cambridge University Press, 2010.
Reznikov, M.I., Lipov, Yu.M., Steam Boilers of Thermal Power Plants, Mir Publishers, Moscow, 1985.
Whalley, P.B., Two-Phase Flow and Heat Transfer, Oxford Science Publications, Oxford, 1996.
Delhaye, J.M., Thermohydraulics of Two-Phase Systems for Industrial Design and Nuclear Engineering, Hemisphere, 1981.
Stevanović, V., Thermal-Hydraulics of Steam Generators – Modelling and Numerical Simulation, Monograph, Faculty of Mechanical Engineering, Belgrade, 2006, ISBN 86-7083-569-X.

Steam Turbines 1

ID: MSc-0274
teaching professor: Петровић В. Милан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: thermal power engineering

goals

1. The achievement of academic competence in the field of steam turbines and thermal power engineering.
2. The achievement of theoretical knowledge about how to transform heat into mechanical work learning thermodynamic processes and equipment (steam turbine and steam turbine power plants).
3. The acquisition of practical knowledge to optimize thermodynamic cycle and steam turbines.
4. The achievement of the techniques of process modeling.
5. Mastering the methods of experimental work in thermal power engineering.

learning outcomes

1. Academic deep knowledge of the thermodynamic cycle and flows in steam turbines and steam turbine plants
2. The development of critical thinking about energy use, fuel efficiency and environmental preservation
3. The ability of calculate heat balance diagrams and main parameters of the steam turbine power plants.
4. Ability to use computer technology for modeling and calculations

theoretical teaching

Theoretical teaching is carried out through 10 teaching modules:
1) Thermodynamic background of the steam and steam turbine plants. Thermodynamic improvement, a increase of temperature and pressure of the live steam, condensation, and condensation pressure deceasing.
2) Reheat. Regenerative feed water heating. The basic thermodynamic cycles and heat balance diagrams.
3) Steam turbine power plant -the 1st and 2nd law of thermodynamics.
4) The fluid dynamics background of steam turbines, gas-dynamic processes in steam turbines.
5) Cascades of the steam turbine. Geometry and operating parameters. The main gas-dynamic parameters of the steam turbines cascades.
6) The aerodynamic losses in the cascades.
7) 1D theory of elementary stages of steam turbines. Euler equation for the turbine. Efficiency of the stage.
8) Axial elementary pressure stage.
9) Axial of elementary impulse stage reaction Parsons.
10) Internal efficiency of the stage. Internal losses. Determination of main dimensions of stage.

practical teaching

Practical teaching is carried out through:
Auditory exercises: basic principles. Historical development. Classification and application of steam turbines. Explanation of the heat balance diagrams and the functioning of components of

the steam turbine plants. Instructions for calculation of the heat balance diagram and the main thermodynamic parameters of the steam turbine plants. Instruction to create an energy and exergy balance of the steam turbine plant according to the 1st and the 2nd law of thermodynamics.
Labs: Experimental determination of the specific steam consumption of steam turbines at the Laboratory of Mechanical Engineering.
Project design: Calculation of the heat balance diagram, the main thermodynamic parameters and the balance of the steam turbine plant.

prerequisite

Passed exams in Thermodynamics and Fluid mechanics

learning resources

Petrovic, M.: Steam turbines, script, 2004.
Vasiljevic, N.: Steam turbines Faculty of Mechanical engineering, Belgarde, 1987.
Petrovic, M.: Instruction for steam turbine projet, Belgrade, 2004
Petrovic, M.: Scripts and handouts for Steam turbines
Instructions for performing laboratory exercises
Software package for calculating of properties of steam and water.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 9
laboratory exercises: 4
calculation tasks: 0
seminar works: 0
project design: 13
consultations: 4
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 1
check and assessment of seminar works: 0
check and assessment of projects: 7
colloquium, with assessment: 2
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 10
laboratory exercises: 5

calculation tasks: 0
seminar works: 0
project design: 30
final exam: 50
requirements to take the exam (number of points): 25

references

Petrovic, M.: Steam turbines, script, 2004.
Stojanovic, Themal Turbomachinery, Gradjevinska knjiga, belgrade, 1967.
Vasiljevic, N.: Steam turbines, Faculty of Mechanical Engineering, Belgarde, 1987.
Traupel,W.: Thermische Turbomaschinen, Springer verlag, Berlin, 1982
Leyzerovich, A.: Steam Turbines for Modern Fossil-Fuel Power Plants, CRC Press, 2008

Steam Turbines 2

ID: MSc-0174
teaching professor: Петровић В. Милан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: thermal power engineering

goals

1. The achievement of academic competence in the field of steam turbines and thermal power engineering.
2. The achievement of theoretical knowledge about how to transform heat into mechanical work learning thermodynamic processes and equipment (steam turbine and steam turbine power plants).
3. The acquisition of practical knowledge to optimize thermodynamic cycle and steam turbines.
4. The achievement of the techniques of process modeling.
5. Mastering the methods of experimental work in thermal power engineering.

learning outcomes

1. Academic deep knowledge of the thermodynamic cycle and flows in steam turbines and steam turbine plants
2. The development of critical thinking about energy use, fuel efficiency and environmental preservation
3. The ability of calculate the steam turbines.
4. Ability to use computer technology for modeling and calculations.
5. Ability to apply experimental methods in development and practice.

theoretical teaching

Theoretical teaching is carried out through 10 teaching modules:
1) 3D Flow flow in stages of steam turbines.
2) 3D flow in sgae with large length of blades.
3) Design of steam turbines.
4) Multistage steam turbines.
5) The blades of steam turbines - design, stress, constant strain blades, vibration and erosion.
6) Steam turbine rotors - construction, strain, vibration.
7) Housing of steam turbines - design, stress, deformation and thermal dilation. Commissioning of steam turbines in operation, heating, cooling.
8) Steam turbine bearings - design, lubrication. Labyrinth seals. Protection components of steam turbines.
9) Operating characteristics of steam turbines, cone of consumption.
10) The regulation of steam turbines, thermodynamic and functional problems.

practical teaching

Practical training is carried out through:
Auditory exercises:
Instructions for the project. Calculation and construction of steam turbines. Select profile blades. Design turbine of high, medium and low pressure. Calculation of the number of stages. Calculation of the last stage turbine.

Labs:
Measurement of vibration of the rotor and the frequency of free oscillations of blades of steam turbines at the Laboratory of Mechanical Engineering.
Project development:
Calculation and design of steam turbines
Boat:
Visit one thermal power plant in Serbia

prerequisite

Passed exams in Thermodynamics and Fluid mechanics

learning resources

Petrovic, M.: Steam turbines, script, 2004.
Vasiljevic, N.: Steam turbines Faculty of Mechanical engineering, Belgarde, 1987.
Petrovic, M.: Instruction for steam turbine projet, Belgrade, 2004
Petrovic, M.: Scripts and handouts for Steam turbines
Instructions for performing laboratory exercises
Software package for calculating of properties of steam and water.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 14
laboratory exercises: 4
calculation tasks: 0
seminar works: 0
project design: 12
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 1
check and assessment of seminar works: 0
check and assessment of projects: 7
colloquium, with assessment: 2
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 10
laboratory exercises: 5
calculation tasks: 0

seminar works: 0
project design: 30
final exam: 50
requirements to take the exam (number of points): 25

references

Petrovic, M.: Steam turbines, script, 2004.
Stojanovic, Themal Turbomachinery, Gradjevinska knjiga, belgrade, 1967.
Vasiljevic, N.: Steam turbines, Faculty of Mechanical Engineering, Belgarde, 1987.
Traupel,W.: Thermische Turbomaschinen, Springer verlag, Berlin, 1982
Leyzerovich, A.: Steam Turbines for Modern Fossil-Fuel Power Plants, CRC Press, 2008

Technical and Technological Development and Innovation Activity

ID: MSc-0585
teaching professor: Стевановић Д. Владимир
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: thermal power engineering

goals

The aims of the subject are mastering the methods for the planning and conducting technical and technological development and innovative project, as well as acquiring knowledge in the corresponding fields, such as intellectual property, patent rights, legal regulations, economic evaluation of innovative projects etc.

learning outcomes

Students acquire knowledge about development mechanisms of technical, technological and innovative development, methods for planning, control and conducting of development projects and research, about economic evaluation of investment, intellectual property, patent and production rights.

theoretical teaching

Dependence between social, economic and technological development. Innovative activities. Theories of development processes and application in technical and technological activities. Mechanisms of technological development and innovation activities: entrepreneurship, Technological development and innovations, development of knowledge, knowledge dissemination, research conductance, development and market, utilization of financial and human resources. Innovation strategy. Methods and activities of innovation projects: problem definition, methods of technical and technological development and innovative activities, organization and conductance of development and innovation, interdisciplinary of development tasks, marketing of research and results promotion. Models for innovative projects conductance. Economic evaluation of investments. Risk analyses. Intellectual property and patent rights. National and international law regulations for patent rights. Business plans of innovative projects. Organization of technical and technological activities on the system level, state regulations and support measures. Cooperation of economic, research and development and state entities in the field of technical, development and innovative activities.

practical teaching

Examples of technical and technological development in certain fields of mechanical engineering: invention, new theory, prototype, technical applications, market development. Patent application. Requirements for a patent application. Intellectual rights conductance.

prerequisite

Passed at least one exam at the module.

learning resources

Lecture handouts, articles from technical and scientific journals, national and international acts, directives and law regulations.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 10
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 8
consultations: 6
discussion and workshop: 6
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 5
colloquium, with assessment: 3
test, with assessment: 2
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 30
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 35
final exam: 30
requirements to take the exam (number of points): 35

references

The law of industrial property, Society of engineers and technicians of Yugoslavia, Belgrade, 1990.
Lj. Radosavljević, Intelectual property in Serbia, Institut IMS, Belgrade, 2005.
M.P. Hekkert, et al., Functions of innovation systems: A new approach for analyzing technological change, Technological Forecasting and Social Change, 74 (2007) 413-432.
M.S. Poole, A.H. Van de Ven, K. Dooley, M.E. Holmes, Organizational Change and Innovation Processes, Theories and Methods for Research, Oxford University Press, 2000.
S.O. Negro, Dynamics of Technological Innovation Systems - The Case of Biomass Energy, Copernicus Institute for Sustainable Development and Innovation, Utrecht, 2007.

Thermal Power Plants

ID: MSc-0194
teaching professor: Савић М. Бранислав
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: thermal power engineering

goals

Familiarizing with the procedures of choosing type and sort, parameters and configuration of a thermal power plant, according to requirements of energy consumption, available sources of primary energy, energetic and economic performances and other relevant criteria. Furthermore, gaining knowledge on functional and technological characteristics of certain technological thermal power plant systems. The practice course is based on the implementation of certain practical knowledge from the course program, by solving specific examples.

learning outcomes

The program provides the practical knowledge a graduated mechanical engineer needs in order to work in the field of thermal power engineering, which enables him to solve certain practical problems more easily and quickly. Such competence includes mastering the procedures of analytic and synthetic consideration of choice of type and sort of thermal power plant in the procedure of planning and design, as well as inclusion into the process of exploitation and maintenance.

theoretical teaching

Influence of the main factors and criteria on the choice of a thermal power plant. Structure and characteristics of final energy consumption. Choice of configuration and parameters of a thermal power plant: basic and principle thermodynamic parameters for the steam and gas unit, thermodynamic improvements to the steam and gas unit. Calculation of production costs and criteria for the optimization of a thermal power plant: overall energy production costs, comparative economy factors as criteria for optimization and economic indicators of profitability. Thermal power plant as a complex technological system. Technological scheme of a thermal power plant. Technological scheme of the main electrical energy production system, which includes the functions of starting and stopping the unit. Particular attention is given to main auxiliary technological systems: for fuel supply, for drainage, transport and storage of ashes and slag, condensation plant with a cooling water supply system and the steam unit control and management system.

practical teaching

The practical course includes a demonstration laboratory exercise with a visit to a thermal power plant, in order to familiarize with the main technological electric energy production system (turbo-generator and boiler plant), as well as the most important auxiliary technological systems. Includes completing three calculation tasks, related to the calculation of production costs and price of a produced unit of electric energy, creation of an elaborate technological scheme of the main cycle of the thermal power plant and application of comparative economy factors on the optimization of the thermal power plant. Knowledge assessment is conducted through 3 stipulated tests in the theoretical aspect of the course, review and evaluation of the calculation tasks and reports on the visit to the thermal power plant.

prerequisite

Passed exams in Steam and Gas turbines are desirable.

learning resources

Written extracts from the lectures:
1. Kostyuk, A. and Frolov V.: Steam and Gas Turbines, Energoatomizdat, Mir Publishers Moscow, 1988.-КСЈ
2. Rižkin, V.: "Тепловие електрические станциј", Energoatomizdat, Moscow, 1987.-КСЈ
3. Stojanović, D.: "Toplotne turbomašine", Građevinska knjiga, Belgrade, 1973. - KDA
4. Vasiljević, N., Savić, B., Stojaković, M.: "Istraživanje optimalnih projektnih i eksploatacionih uslova rada kondenzacijskog dela parnih turbopostrojenja", Faculty of mechanical engineering, Belgrade, 1991. - KPN
5. Schroeder, K: Grosse Dampftkraftwerke, Springer Verlag, Berlin, 1962
6. CEGB: Modern Power Station Practice, Pergamon press, Oxford, 1971

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 6
laboratory exercises: 5
calculation tasks: 17
seminar works: 0
project design: 0
consultations: 2
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 8
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 2
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 25
laboratory exercises: 5
calculation tasks: 25
seminar works: 0
project design: 0
final exam: 35
requirements to take the exam (number of points): 30

references

1. Kostyuk, A. and Frolov V.: Steam and Gas Turbines, Energoatomizdat, Mir Publishers Moscow, 1988. - КСЈ
2. Rižkin, V.: "Thermal power plants", Energoatomizdat, Moscow, 1987.-КСЈ
3. Стојановић, Д.: Steam and gas turbines, Грађевинска књига, Београд, 1973. - КДА
4. Васиљевић, Н., Савић, Б., Стојаковић, М.: Research of optimal design and exploitation working conditions of cold-end of steam turbine plant, FME, Belgrade, 1991. - КПН
5. Schroeder, K: Grosse Dampftkraftwerke, Springer Verlag, Berlin, 1962

Thermal Turbomachinery

ID: MSc-0337
teaching professor: Петровић В. Милан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: thermal power engineering

goals

1. The achievement of academic competence in the field of steam and gas turbines and thermal power engineering.
2. The achievement of theoretical knowledge about how to transform heat into mechanical work learning thermodynamic processes and equipment (steam and gas turbines and thermal power plants).
3. The acquisition of practical knowledge to optimize thermodynamic cycle and steam and gas turbines.
4. The achievement of the techniques of process modeling.
5. Mastering the methods of experimental work in thermal power engineering.

learning outcomes

1. Academic deep knowledge of the thermodynamic cycle and flows in steam and gas turbines and turbine plants
2. The development of critical thinking about energy use, fuel efficiency and environmental preservation
3. The ability of calculate heat balance diagrams and main parameters of the steam and gas turbine power plants.
4. Ability to use computer technology for modeling and calculations

theoretical teaching

1)Thermodynamic background of the steam turbines and steam turbine power plants. Thermodynamic improvements of the thermodynamic cycles.
2) Reheat. Regenerative feed water heating. The basic thermodynamic cycle.
3) Steam turbine power plant -the 1st and 2nd law of thermodynamics.
4) Cascades of the steam turbine. Geometry and operating parameters. The main aerodynamic parameters of the steam turbines cascades.
5) The aerodynamic losses in the cascades.
6) 1D theory of elementary stages of steam turbines. Euler equation for the turbine. Efficiency of the stage
7) Axial action stage. Axial reaction stage. Internal efficiency of the stage. Internal losses degrees.
8) Thermodynamic basis of the gas turbine plant. The basic thermodynamic cycle. The basic and main thermodynamic parameters of the gas block.
9) The influence of basic parameters on the performance of the gas turbine plant. The choice of optimal parameters of the gas turbine plant.
10) Balance of energy of the gas turbine plant. Possibilities to improve the thermodynamic gas turbine plant. More complex configurations of gas turbine plant. Combined gas and steam plant turbine.

practical teaching

Practical teaching is carried out through:

Auditory exercises: basic principles. Historical development. Classification and application of steam turbines. Explanation of the heat balance diagrams and the functioning of components of the steam turbine plants. Instructions for calculation of the heat balance diagram and the main thermodynamic parameters of the steam turbine plants. Instruction to create an energy balance of the steam turbine plant according to the 1st and the 2nd law of thermodynamics.
Labs: Experimental determination of the specific steam consumption of steam turbines at the Laboratory of Mechanical Engineering.
Project design: Calculation of the heat balance diagram, the main thermodynamic parameters and the balance of the steam turbine plant.

prerequisite

Passed exams in Thermodynamics and Fluid mechanics

learning resources

Petrovic, M.: Steam turbines, script, 2004.
Petrovic, M.: Gas turbines and compressors, script, 2004.
Petrovic, M.: Instruction for steam turbine projet, Belgrade, 2004
Petrovic, M.: Scripts and handouts for Steam turbines
Instructions for performing laboratory exercises
Software package for calculating of properties of steam and water.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 14
laboratory exercises: 4
calculation tasks: 0
seminar works: 0
project design: 12
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 1
check and assessment of seminar works: 0
check and assessment of projects: 7
colloquium, with assessment: 0
test, with assessment: 2
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 10

laboratory exercises: 5
calculation tasks: 0
seminar works: 0
project design: 30
final exam: 50
requirements to take the exam (number of points): 25

references

Petrovic, M.: Steam turbines, script, 2004.
Stojanovic, Thermal Turbomachinery, Gradjevinska knjiga, Belgrade, 1967.
Vasiljevic, N.: Steam turbines, Faculty of Mechanical Engineering, Belgarde, 1987.
Petrovic,, Gas turbine and turbocompressors, script, 2004.
Boyce, M.: Gas turbine engineering hadbook, GPB, Boston 2002.

Turbocompressors

ID: MSc-0336
teaching professor: Петровић В. Милан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: thermal power engineering

goals

1. The achievement of academic competence in the field of compressors and thermal power plant engineering.
2. Mastery of theoretical knowledge about how to transform mechanical work into internal energy of fluid by learning of thermodynamic processes and equipment.
3. The acquisition of practical skills for design and optimization of turbocompressors.
4. Mastering the techniques of process modeling.

learning outcomes

1. Academic deep knowledge of the thermodynamic cycle and flows in gas turbines and gas turbine plants
2. The development of critical thinking about energy use, fuel efficiency and environmental preservation
3. The ability to make design of compressors.
4. Ability to use computer technology for modeling and calculations

theoretical teaching

1. Thermodynamic background of turbocompressors. Isothermal, isentropic, polytropic and real process. Isentropic efficiency and polytropic efficiency.
2nd The current basis and processes gas-dynamic turbo-compressors.
3.Cascades of turbocompressors. Geometric and operating parameters of the lattice.
4.Main aerodynamic cascade parameters. Aerodynamic losses of compressor stages.
5.Application of aerodynamic coefficients in cascade teheory.
6.Mean-line theory of compressor stages. Energy balance, Euler equations.
7.Design factors of turbocompressors and dimensionless velocity triangles. Dependence of the degree of compression from the operating parameters.
8.Dependence of efficiency of the normal stages of axial compressor from aerodynamic coefficients and cascade parameters from the working parameters.
9. 3D flow in normal stages of axial compressors. Optimal design factors. Determination of main dimensions of axial compressors.
10. The behavior of the copressors at variable loads. Regulation of turbocompressors.

practical teaching

Practical training is carried out through:
Auditory exercises:
Introduction. Energy conversion in the compressors. The types of compressors. Application areas.
Instructions for project 1: Calculation of main dimensions of axial compressors.
Instructions for project 2: Design of the compressors cascades.
Project development:
Calculation of main dimensions of axial compressors.
Calculation of compressors cascades.

Labs:
Learning the principles of operatin and desing of compressors in Laboratory of steam and gas turbines.

prerequisite

Passed exams in Thermodynamics and Fluid mechanics

learning resources

Petrovic, M.: Gas turbines and compressors, script, 2004.
Petrovic, M.: Gas turbines and compressors, introduction for exercises, 2004.
Petrovic, M. scripts and handouts for Gas turbines
Instructions for performing laboratory exercises
Software package for calculating of properties of air and combustion products

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 9
laboratory exercises: 4
calculation tasks: 0
seminar works: 0
project design: 17
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 1
check and assessment of seminar works: 0
check and assessment of projects: 7
colloquium, with assessment: 2
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 10
laboratory exercises: 5
calculation tasks: 0
seminar works: 0
project design: 30
final exam: 50
requirements to take the exam (number of points): 25

references

Petrovic, M.: Gas turbines and compressors, script, 2004.
Stojanovic, Thermal Turbomachinery, Gradjevinska knjiga, belgrade, 1967.
Cohen, H., Rogers,G.F.C., Saravanamuttoo, H.I.H.: Gas turbine theory, Logman, 1997.
Traupel,W.: Thermische Turbomaschinen, Springer verlag, Berlin, 1982
Boyce, M.: Gas turbine engineering hadbook, GPB, Boston 2002.

Two-Phase Flows with Phase Transition

ID: MSc-0325
teaching professor: Стевановић Д. Владимир
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: thermal power engineering

goals

The aim is acquiring academic knowledge about two-phase flow patterns, mechanisms of transport processes in two-phase flows, intensity of evaporation and condensation and methods for two-phase flows simulation and analyses within design, safety analyses and prescription of operating conditions and parameters of energy plants.

learning outcomes

The students are trained to perform computer simulation and analyses of gas-liquid two-phase flows within design of energy plants, safety analyses, operating conditions diagnostics, defining of operating conditions, etc.

theoretical teaching

Two-phase flow patterns and related maps. Two-phase flow modeling by multi-fluid models and corresponding closure laws for interface transport processes. Mechanisms of pressure change in two-phase flow and prediction methods. The effect of flooding in counter-current gas-liquid flow. Pool boiling and convective boiling. The critical heat flux and prediction methods. Condensation of pure vapour and condensation in the presence of noncondensables. Sonic waves propagation in two-phase flow. The chocked two-phase flow. Numerical methods for the solving of two-phase flow models. Computation of two-phase flows in components of energy and process plants.

practical teaching

Prediction of two-phase flow parameters: static, flow and thermodynamic quality, void fraction, two-phase flow density, superficial velocity, slip factor, drift velocity, etc. Empirical correlations for the prediction of void fraction, slip factor and drift velocity. The influence of the pressure level on the two-phase flow parameters. Prediction of pressure change in two-phase flow. Development of multi-fluid models of two-phase flow: balance equations, closure laws and solving methods. Application of the multi-fluid two-phase flow model to energy and process equipment, such as: evaporating channel, condensation in a pipe, heat exchangers with phase transitions, evaporators, steam boilers with boiling around tubes in a bundle, evaporating tubes in steam boiler furnace, condensers, pressurizers, feedwater tanks, steam boiler drum, steam accumulator, pipelines, etc.

prerequisite

Passed exams in Thermodynamics, Fluid Mechanics and Numerical Methods.

learning resources

Course handouts.
Computer equipment.
Computer codes for thermal-hydraulic simulations of two-phase flows and pressure transients

in pipelines, pressurized vessels, heat exchangers with boiling or condensation in tube bundles.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 15
laboratory exercises: 15
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 5
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 5
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 35
laboratory exercises: 30
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

Whalley, P.B., Two-Phase Flow and Heat Transfer, Oxford University Press, Oxford, 1996.
Wallis, G.B., One-Dimensional Two-Phase Flow, McGraw-Hill, New York, 1969.
Clift, R., Grace, J.R., Weber, M.E., Bubbles, Drops and Particles, Academic Press, New York, 1978.
Delhaye, J.M., Giot, M., Rietmuller, M.L., Thermalhydraulics of Two-Phase Systems for Industrial Design and Nuclear Engineering, McGraw-Hill, 1981.
Stevanovic, V., Thermal-Hydraulics of Steam Generators – Modelling and Numerical Simulation, University of Belgrade, Faculty of Mechanical Engineering, 2006.

ID: MSc-0356
teaching professor: Савић М. Бранислав
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 1
final exam: seminar works
parent department: thermal power engineering

goals

Practical experience and residence in an environment where students will be able to realize their professional careers.
Recognizing the principle functions of a business system in the domain of design, development and production, as well as the role and tasks of a mechanical engineer in such a business system.

learning outcomes

Students gain practical experience regarding the means of organizing and functioning of the environments in which they will apply the gained knowledge in their future professional careers. Students will be able to recognize models of communication with colleagues and business information flows. Students will be able to recognize the basic processes in design, production, maintenance, in the context of their future professional competencies. Personal contacts and acquaintances are made, which they will be able to use during their studies, or when starting their professional careers.

theoretical teaching

practical teaching

Practical work involves working in organizations in which various activities related to mechanical engineering are conducted. The choice of the thematic unit and business or research organization is conducted in consultation with the subject professor. Generally, a student can have practice in: production organizations, design and consulting organizations, organizations which maintain mechanical equipment, public and utility companies, as well as one of laboratories at the faculty of mechanical engineering. Practice can be conducted abroad, as well. During practice, students are obliged to keep a diary, in which they will describe the work they conduct, as well as conclusions and observations. After the completed practice, they must comply a report which they will defend before their subject professor. The report is submitted in the form of seminar work.

prerequisite

learning resources

number of hours

total number of hours: 46

active teaching (theoretical)

lectures: 0

active teaching (practical)

auditory exercises: 0
laboratory exercises: 0

calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 0
final exam: 46

assessment of knowledge (maximum number of points - 100)

feedback during course study: 70
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

thermal science engineering

Central Heating Systems

ID: MSc-0661
teaching professor: Тодоровић Н. Маја
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: thermal science engineering

goals

Acquiring knowledge and skills in the field of central heating - hot water two-pipe systems with natural and forced circulation of hot water, hot water one-pipe systems, steam heating system of low pressure, air heating, panel heating, district heating, solar systems, mastering the methods for calculation of pipe network.

learning outcomes

Students acquire specific skills and knowledge of central heating systems: knowledge of different heating systems, known methods of calculation of central heating systems and can apply them in practice. Connects basic knowledge and apply it to solve concrete problems in the technique of heating.

theoretical teaching

Two-pipe hot water central heating pump systems, pipe heating system; correction of surface heaters, heating steam low pressure, upper and lower divorce; Steam traps, condensate return to boiler; calculation of pipe networks, heat transfer by radiation; panel heating systems, heat transfer from the budget tube, through multi-layered plate, the surrounding air, underfloor heating, air heating, ventilation chamber and its components, industrial ventilation, remote distribution of heat; characteristics of district heating, heat transport distance; substation for direct and indirect connection; heating sliding diagrams, renewable energy sources, active and passive use of solar energy and geothermal energy.

practical teaching

Auditory exercises consist of parts: pipe sizing for two-pipe hot-water network system with natural and forced circulation of water in the system and facilities 90/70oC to prepare and distribute hot water, and to individual work of reference. Lab exercise - testing thermal properties of heaters; temperature impact on the heat output of radiators; influence of the flow rate to heat output of radiators; behavior of heaters in non-stationary conditions (visit the exhibition of thermal engineering in the Congress of HVAC or visit the factory).

prerequisite

In order for a student attending the subject must have passed the exams in the subject: Thermodynamics B and Heating technique Fundamentals

learning resources

Handouts - M. Todorović
B. Todorović - Central Heating Systems Design - Faculty of Mechanical engineering, Belgrade, 2009.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 10
laboratory exercises: 5
calculation tasks: 0
seminar works: 0
project design: 15
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 5
colloquium, with assessment: 5
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 30
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 20
final exam: 50
requirements to take the exam (number of points): 21

references

B. Todorović - Central Heating Systems Design - Faculty of Mechanical engineering, Belgrade, 2009.

Energy certification of buildings

ID: MSc-0667
teaching professor: Тодоровић Н. Маја
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: thermal science engineering

goals

Acquiring knowledge and skills in the field of energy certification of buildings - the concept of energy building certificate, building energy consumption, energy needs and significant parameters; comfort conditions and design parameters, central heating and air conditioning systems, energy sources, final and primary energy, domestic hot water systems; optimization of HVAC systems and the application of passive techniques, methodology of calculation of indicators, classification of buildings by type and energy codes; elaboration of energy efficiency, energy certificate.

learning outcomes

Students acquire specific skills and knowledge in the field of energy certification of buildings; known methods for the calculation of indicators to determine the energy code of the building and can be applied in practice. Connects the basic knowledge and applies them to the elaboration of energy efficiency of the building.

theoretical teaching

The concept of energy building certificate, Energy Performance of Buildings Directive – main objectives; building energy consumption, energy needs and significant parameters; comfort conditions and design parameters, central heating and air conditioning systems, energy sources, final and primary energy, domestic hot water systems; optimization of HVAC systems and the application of passive techniques, application of renewable energy sources, methodology of calculation of indicators, classification of buildings by type and energy codes; energy audit, elaborate of building energy efficiency, building energy certificate.

practical teaching

Auditory exercises consist of parts: Example of calculation of thermal properties of elements of the building envelope - the determination of the coefficient of thermal conductivity, specific transmission and ventilation losses, building shape factor, design conditions and schadules of use of technical systems, determination of energy needs and indicators that define the energy code; application measures to improve energy efficiency of buildings - individual measures and measure sets improvement, financial analysis.

Individual Project task – Elaborate on energy efficiency of building on the example of residential building.

prerequisite

No conditions

learning resources

M. Todorović: Energy certification of buildings - handouts

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 15
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 10
consultations: 5
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 5
colloquium, with assessment: 5
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 30
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 20
final exam: 50
requirements to take the exam (number of points): 21

references

M. Todorović: Energy certification of buildings, handouts

Energy Steam Boilers 1

ID: MSc-0289
teaching professor: Туцаковић Р. Драган
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: thermal science engineering

goals

Reaching the competence and academic skills and methods for it's acquiring. Developing creative capabilities and mastering the specific practical skills. Goals determine the specific results which should be achieved within the subject. Goals also represent basis for control of the achieved results. Activities in this subject are in accordance with basic tasks and goals of the study program.

learning outcomes

Student acquires specific capabilities which are needed for carrying out professional activities: analysis, synthesis and anticipating the results and consequences; use of knowledge from different areas for solving specific problems.

theoretical teaching

Worikng principle of a steam boiler and definitions of basic concepts; Fuels for steam boilers; Combustion material balance; Excess air; Flue gases enthalpy; Steam boiler heat balance, losses and efficiency; Steam boiler furnace; Steam boiler evaporators with natural and forced circulation loop; Half-radiation and convection evaporators; Radiation, half-radiation and convection superheaters; Reheaters; Different types of water heaters; Recuperative air heaters and regenerative air heaters.

practical teaching

Auditory exercises consist from demonstration exercises(classification of boilers; steam boiler construction; main and auxiliary devices and equipment); Working project - coal combustion material balance (coal calorific value, theoretical air volume for combustion , theoretical flue gas volume,
flue gases enthalpy diagram as a function of temperature and excess air); worikng principle of a industrial steam boiler; wetermining the losses, efficiency and fuel consumption of the given steam boiler; furnace dimensioning; heat and material balance of steam boiler heating surfaces.

prerequisite

Necessary condition: Bachelor's degree

learning resources

Books: Lj. Brkic, T. Zivanovic, D. Tucakovic: Steam Boilers, Faculty of Mechanical Engineering, Belgrade, 2010, (In Serbian); Lj. Brkic, T. Zivanovic, D. Tucakovic: Steam Boilers Thermal Calculation, Faculty of Mechanical Engineering, Belgrade, 2010, (In Serbian); handouts which will be at student's disposal a week in advance

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 10
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 10
consultations: 0
discussion and workshop: 10
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 4
colloquium, with assessment: 6
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 30
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 30
final exam: 40
requirements to take the exam (number of points): 30

references

Lj. Brkic, T. Zivanovic, D. Tucakovic: Steam Boilers, Faculty of Mechanical Engineering, Belgrade, 2010, (In Serbian)
Lj. Brkic, T. Zivanovic, D. Tucakovic: Steam Boilers Thermal Calculation, Faculty of Mechanical Engineering, Belgrade, 2010, (In Serbian)

Energy Steam Boilers 2

ID: MSc-0313
teaching professor: Туцаковић Р. Драган
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: thermal science engineering

goals

Reaching the competence and academic skills and methods for it's acquiring. Developing creative capabilities and mastering the specific practical skills. Goals determine the specific results which should be achieved within the subject. Goals also represent basis for control of the achieved results. Activities in this subject are in accordance with basic tasks and goals of the study program.

learning outcomes

Student acquires specific capabilities which are needed for carrying out professional activities: analysis, synthesis and anticipating the results and consequences; use of knowledge from different areas for solving specific problems.

theoretical teaching

Thermal calculation of the steam boiler heating surfaces; Devices for fuel bed combustion - flat grate stoker, chain grate stoker, inclined grate stokers; Coal dust preparation systems; Mill processes; Heat and material balance of coal drying process in mills; Mill constructions; Coal dust separators; Mill gas classifiers; Coal dust burners; Aerodynamic of the air and flue gas tract (balanced draft boiler, forced draft boiler and natural draft boiler, choice of fan and it's regulation); Hydrodynamics of steam boiler (hydrodynamics of water heater, evaporator and superheater).

practical teaching

Auditory exercises consist from demonstration exercises (Classification and construction of steam boilers with appropriate heating surfaces, auxiliary devices and equipment); Working project - Thermal calculation of industrial steam boiler; Thermal calculation and dimensioning of heating surfaces (furnace, convection evaporator, convection superheaters, water heater and air heater); After dimensioning steam boiler heating surfaces, it's necessary to make steam boiler drawing in three sections.

prerequisite

Necessary condition: Bachelor's degree and passed Energy Steam Boilers 1

learning resources

Books: Lj. Brkic, T. Zivanovic, D. Tucakovic: Steam Boilers, Faculty of Mechanical Engineering, Belgrade, 2010, (In Serbian); Lj. Brkic, T. Zivanovic, D. Tucakovic: Steam Boilers Thermal Calculation, Faculty of Mechanical Engineering, Belgrade, 2010, (In Serbian); handouts which will be at student's disposal a week in advance

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 10
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 10
consultations: 0
discussion and workshop: 10
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 4
colloquium, with assessment: 6
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 30
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 30
final exam: 40
requirements to take the exam (number of points): 30

references

Lj. Brkic, T. Zivanovic, D. Tucakovic: Steam Boilers, Faculty of Mechanical Engineering, Belgrade, 2010, (In Serbian)
Lj. Brkic, T. Zivanovic, D. Tucakovic: Steam Boilers Thermal Calculation, Faculty of Mechanical Engineering, Belgrade, 2010, (In Serbian)

Fundamentals of Air Conditioning

ID: MSc-0304
teaching professor: Живковић Д. Бранислав
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: thermal science engineering

goals

Getting knowledge in Air Conditioning - thermal comfort, heat gain and cooling load, air handling unit and its elements, mastering methods for calculating cooling loads for non-stationary conditions of heat transfer and using those methods in air conditioning project design.

learning outcomes

Student acquires specific abilities and knowledge in air conditioning: he knows the elements of a central air conditioning system, methods of cooling load calculations and he can use it in practice. Student links basic knowledge and apply it in solving concrete problems in air conditioning.

theoretical teaching

Defining air conditioning; thermal ambiance conditions; thermal comfort in closed spaces; thermal regulation; meteorology and climate; Solar constant; atmosphere clearance; radiation on horizontal and vertical surfaces; outside and inside heat sources; heat transfer through single-layer and multiple-layer walls in non-stationary conditions of heat transfer; heat gains from solar radiation through window; heat storage factors; protection from solar radiation; shading effect on cooling load; heat gains from internal sources; calculation air flow rate for air conditioning; air treatment in air handling unit; air handling unit and its elements; heating and cooling coil; heat output control of heating and cooling coil; spraying chamber; evaporator; filtration; filter efficiency;

practical teaching

Auditory part consists of more sections: basic and complex processes in
Molier h-x diagram, calculating cooling load from inside and outside heat sources, calculating airflow rate for air conditioning, defining air parameters in summer and winter operating mode, in order to independently complete project assignment. Laboratory exercise is demonstrative - air handling unit and its elements, air conditioning accessoris. Visit to Technical fair or factory for air conditioning equipment is planned.

prerequisite

In order to attend this subject, it is needed to pass exams: Thermodynamic and Fluid mechanics.

learning resources

Handouts

B.Todorovic: Air conditioning

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 10
laboratory exercises: 5
calculation tasks: 0
seminar works: 0
project design: 15
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 5
colloquium, with assessment: 5
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 30
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 20
final exam: 50
requirements to take the exam (number of points): 21

references

ASHRAE Handbook of Fundamentals, Atlanta, Georgia, 2009
Recknagel, Sprenger, Schramek, Ceperkovic: Heating and Air Conditioning, Interklima, Vrnjačka Banja, 2002

Heading Systems

ID: MSc-0353
teaching professor: Живковић Д. Бранислав
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: thermal science engineering

goals

Acquiring knowledge and skills in the field of central heating technique - hot water two-pipe systems with natural and forced circulation of hot water, one-pipe hot water systems, low pressure steam heating system, air heating, panel heating, district heating, solar systems, the methods for pipe network sizing.

learning outcomes

Students acquire specific skills and knowledge of heating systems: knowledge of different heating systems, known methods of calculation of central heating systems and can apply them in practice. Student connects basic knowledge and apply it to solve concrete problems in the heating technique.

theoretical teaching

Two-pipe hot water central heating pump systems, one-pipe heating system; correction of radiators surface, low pressure steam heating systems, upper and lower fluid distribution; Steam traps, condensate return to boiler; calculation of pipe networks, heat transfer by radiation; panel heating systems, heat transfer from the pipe through the multi-layer board, floor heating, air heating, air handling unit and its elements, industrial ventilation, district heating systems; characteristics of district heating, transport of heat at a distance; substation for direct and indirect connection; sliding heating diagrams, renewable energy sources, active and passive use of solar energy and geothermal energy.

practical teaching

Auditory exercises consist of several parts: pipe network dimensioning for two-pipe hot water system with natural and forced circulation of water in the system 90/70oC and plant for domestic hot water in order to prepare individual mechanical design of heating system. Lab exercise - testing thermal properties of radiator; effect of temperature on the radiators heat output; influence of the flow rate to radiators heat output; behavior of heating bodies in non-stady state conditions (visit the exhibition of HVAC fair in the KGH Congress, or visit the HVAC factory).

prerequisite

Student must have passed the exams from the courses: Fundamentals of Thermodynamics and Heating technique fundamentals.

learning resources

Lecture handouts

Textbook: B. Todorovic: Designing systems for central heating, Faculty of Mechanical Engineering, Belgrade, 2007.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 10
laboratory exercises: 5
calculation tasks: 0
seminar works: 0
project design: 15
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 5
colloquium, with assessment: 5
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 30
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 20
final exam: 50
requirements to take the exam (number of points): 21

references

B. Todorovic: Designing systems for central heating, Faculty of Mechanical Engineering, Belgrade, 2007.
Recknagel, Sprenger, Schramek, Ceperkovic: Heating and Air Conditioning, Interklima, Vrnjacka Banja, 2002

Heat Pumps

ID: MSc-0166
teaching professor: Коси Ф. Франц
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: thermal science engineering

goals

Achieving of competence and academic skills as well as methods for their acquisition. The development of creative abilities and practical skills which are essential to the profession. Objectives are concrete and achievable and in full accordance with the defined basic tasks and objectives of the study program.

learning outcomes

Student acquires subject-specific abilities that are essential for the quality of professional activities: analysis, synthesis and prediction of solutions and consequences; application of knowledge in practice; linking the basic knowledge in various fields with their application to solve specific problems.

theoretical teaching

Characteristics of heat pumps: Systematization of thermal systems performing refrigeration cycles, The criteria for evaluation of thermodynamic quality of refrigeration cycles, Heat sources for heat pumps, (atmospheric air, surface water, groundwater and soil, geothermal energy, heat accumulators, solar plate collectors), Thermodinamic improvement of refrigeration cycles; Sorption refrigeration systems; Properties of refrigerant-absorbent mixtures: Basic steady-flow processes with binary mixtures; Basic vapour absorption refrigeration system, (VARS), Steady-flow analysis of the VARS, Maximum COP of ideal absorption refrigeration system, Comparison between compression and absorption refrigeration systems.

practical teaching

Auditory training: systematization of thermal systems performing refrigeration cycles, predicting of heat pumps performaces, mass and heat balance of drying processing, determination of characteristics of the heat pump elements, (compressor, condenser,evaporator), binary mixtures, the basic operations with binary mixtures, thermodynamic calculation of single effect VARS, Laboratory exercise: demonstration of heat pumps for air conditioning system of a hotel building; Design project of heat pump system: work in groups of 5 students (for a particular object and refrigerant), calculation and selection of elements of heat pump, Analysis of complete vapour compression heat pump plant.

prerequisite

Necessary passed the test: Refrigeration Equipment, Refrigeration Systems

learning resources

Textbook: M. Markoski: Air-conditioning, Mechanical Engineering, 2006,
"Handouts" which will be available in advance for each week of classes

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 10
laboratory exercises: 5
calculation tasks: 0
seminar works: 0
project design: 15
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 5
colloquium, with assessment: 5
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 30
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 20
final exam: 50
requirements to take the exam (number of points): 21

references

Marine Turbines and Boilers

ID: MSc-0121
teaching professor: Туцаковић Р. Драган
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 2
final exam: written+oral
parent department: thermal science engineering

goals

Reaching the competence and academic skills and methods for it's acquiring. Developing creative capabilities and mastering the specific practical skills. Goals determine the specific results which should be achieved within the subject. Goals also represent basis for control of the achieved results.

learning outcomes

Student acquires specific capabilities which are needed for carrying out professional activities: analysis, synthesis and anticipating the results and consequences; use of knowledge from different areas for solving specific problems.

theoretical teaching

Introduction; Efficiency and consumption of steam, heat and fuel for marine steam boiler; Fossil fuels marine steam boilers - fuel, combustion material balance, flue gases enthalpy, marine boiler heat balance; Marine waste heat boilers – in general; Thermodynamic cycles and heating block diagram; Basis and the main thermodynamic parameters of steam turbine plants; transformation of energy in steam turbines; Steam turbines basic elements; Characteristic of gas turbines and use for ship drive; Thermodynamic cycles and thermal cycles of the gas turbine plants. Basis and the main thermodynamic parameters of the gas turbine plants. Elements of gas turbines. Combined cycle of gas turbines and steam turbine.

practical teaching

Auditory exercises consist from demonstration exercises - (Boiler division by steam and water mixture flow in the evaporator; Marine steam boiler construction; Marine steam block boilers; Water tube boiler; Fossil fuel marine boiler placing; Marine waste heat boilers construction; Basics of nuclear propulsion; Presentation of steam turbines design and their application; presentation of gas turbines design and their application); Working assignement - Calculation of main thermodynamic parameters and heating block diagram; Determining the losses, efficiency and fuel consumption of the given marine steam boiler.

prerequisite

Necessary condition: Bachelor's degree

learning resources

Books: Lj. Brkic, T. Zivanovic, D. Tucakovic: Steam Boilers, Faculty of Mechanical Engineering, Belgrade, 2010, (In Serbian); Lj. Brkic, T. Zivanovic, D. Tucakovic: Steam Boilers Thermal Calculation, Faculty of Mechanical Engineering, Belgrade, 2010, (In Serbian); Vasiljević, N.: Steam turbines, Faculty of Mechanical Engineering, Belgrade, 1987; Petrović, M.: Steam turbines – Instructions for exercises, Faculty of Mechanical Engineering, Belgrade, 2004.; Petrović, M.: Gas turbines and compressors (textbook); handouts which will be at student's disposal a week in advance

number of hours

total number of hours: 30

active teaching (theoretical)

lectures: 12

active teaching (practical)

auditory exercises: 8
laboratory exercises: 0
calculation tasks: 4
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 1
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 10
laboratory exercises: 0
calculation tasks: 30
seminar works: 0
project design: 0
final exam: 50
requirements to take the exam (number of points): 25

references

Lj. Brkic, T. Zivanovic, D. Tucakovic: Steam Boilers, Faculty of Mechanical Engineering, Belgrade, 2010, (In Serbian)
Lj. Brkic, T. Zivanovic, D. Tucakovic: Steam Boilers Thermal Calculation, Faculty of Mechanical Engineering, Belgrade, 2010, (In Serbian)
Vasiljević, N.: Steam turbines, Faculty of Mechanical Engineering, Belgrade, 1987. (in serbian)

Professional practice M - TTA

ID: MSc-0357
teaching professor: Тодоровић Н. Маја
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 1
final exam: seminar works
parent department: thermal science engineering

goals

Practical experience and the student presence in the environment in which the student will realize his professional career.
Identifying the basic functions of the business system in the field of design, development and production, as well as the roles and tasks of mechanical engineer in such a business system.

learning outcomes

Students get practical experience on the organization and functioning of the environment in which they will apply their knowledge in their future professional career. Student identifies models of communication with colleagues and business information flows. The student recognizes the basic processes in the design, manufacture, maintenance, in the context of his future professional competence. Students are establishing the personal contacts and acquaintances that will be able to use during studies or entering into future employment.

theoretical teaching

no theoretical lectures

practical teaching

Practical work involves work in organizations that perform various activities in scope of mechanical engineering. Selection of thematic areas, commercial or research organizations is carried out in consultation with the concerned teacher. Generally, a student can perform the professional practice in manufacturing organizations, design and consulting organizations, organizations engaged in mechanical equipment maintenance, and public utility companies and some of the laboratories at Faculty of Mechanical Engineering. The practice may also be made abroad. During practice, students must keep a daybook in which enters a description of the performed tasks, the conclusions and observations. Following the practice, a report must be handed over and defended before the subject teacher. The report is submitted in the form of the daybook.

prerequisite

no condition

learning resources

Handouts and documents obtained by the expert from the organization where the practice is done.

number of hours

total number of hours: 46

active teaching (theoretical)

lectures: 0

active teaching (practical)

auditory exercises: 0
laboratory exercises: 40
calculation tasks: 0
seminar works: 5
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 0
final exam: 1

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 0
laboratory exercises: 30
calculation tasks: 0
seminar works: 40
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

Refrigeration Equipment

ID: MSc-0291
teaching professor: Коси Ф. Франц
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: thermal science engineering

goals

AAchieving of competence and academic skills as well as methods for their acquisition. The development of creative abilities and practical skills which are essential to the profession. Objectives are concrete and achievable and in full accordance with the defined basic tasks and objectives of the study program.

learning outcomes

Student acquires subject-specific abilities that are essential for the quality of professional activities: analysis, synthesis and prediction of solutions and consequences; application of knowledge in practice; linking the basic knowledge in various fields with their application to solve specific problems.

theoretical teaching

Refrigeration compressors (systematization, application); Reciprocating refrigeration compressors: basic elements, basic parameters of operation, operating characteristics (performance) of reciprocating refrigeration compressors, processes in an Ideal and actual compressor, volumetric efficiency, Actual compression process, Capacity control of reciprocating compressors); Rotary refrigeration compressors, twin screw compressors; Auxiliary apparata and refrigeration pipelines, Condensers: classification of condensers, analysis of condensers; Evaporators: classification, direct expansion fin-and-tube type evaporators, flooded evaporators, evaporator defrosting; Expansion devices: thermostatic expansion valve.

practical teaching

Auditory training: A survey of the application area of certain types of compressors; Volumetric efficiency calculation; The compressor displacement calculation; Capacity control of reciprocating compressors; Design of rotary screw compressors; Compressor performance curves; Calculation of refrigeration load of condensers, Calculation of piping, insulation, safety valves and elements of automation, Laboratory exercise: demonstration of cooling installation in an industrial plant; Design project of refrigeration system: work in groups of 5 students (for a particular object and refrigerant), calculation and selection of elements refrigeration plants.

prerequisite

required exams passed: thermodynamics, the basics of refrigeration

learning resources

Textbook: M. Markoski: Air-conditioning, Mechanical Engineering, 2006,
"Handouts" which will be available in advance for each week of classes

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 10
laboratory exercises: 5
calculation tasks: 0
seminar works: 0
project design: 15
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 5
colloquium, with assessment: 5
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 30
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 20
final exam: 50
requirements to take the exam (number of points): 21

references

Refrigeration in Food Technologies

ID: MSc-0495
teaching professor: Коси Ф. Франц
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: thermal science engineering

goals

Achieving of competence and academic skills as well as methods for their acquisition. The development of creative abilities and practical skills which are essential to the profession. Objectives are concrete and achievable and in full accordance with the defined basic tasks and objectives of the study program.

learning outcomes

Student acquires subject-specific abilities that are essential for the quality of professional activities: analysis, synthesis and prediction of solutions and consequences; application of knowledge in practice; linking the basic knowledge in various fields with their application to solve specific problems.

theoretical teaching

Natural and artificial refrigeration, Application of refrigeration, Vapour compression refrigeration systems, The Carnot vapour compression refrigeration cycle, Improvement of vapour compression cycle, (subcooling, multistage throttling, multistage compression with intercooling), Standard vapour compression refrigeration plants, Refrigerants, refrigerant selection criteria; Designation of refrigerants; Reciprocating refrigeration compressors: Basic elements, basic parameters of operation, operating characteristics (performance) of reciprocating refrigeration compressors; Condensers: classification of condensers; Evaporators: classification, evaporator defrosting; Cooling and quick freezing of food products

practical teaching

Auditory training: Moist air, thermodynamic properties of moist air, Molier's "h-x" diagram, Important psychrometric processes, thermal insulation, selection of insulation materials, the diffusion of water vapor through thermal insulation layer, vapour barrier, calculation of refrigeration load, thermodynamic analyses of refrigeration cycle, Basic calculation for sizing of compressors, condensers and evaporators, process systems for quick freezing and storage of food products; Laboratory Exercise: Demonstration of refrigeration devices in industrial plants; Design project of refrigeration system: work in groups of 5 students (for a particular object and refrigerant), calculation of a refrigeration plant.

prerequisite

required exams passed: Thermodynamics B; desirable Passed Exam: Fluid Mechanics B

learning resources

Textbook: M. Markoski: Air-conditioning, Mechanical Engineering, 2006,
"Handouts" which will be available in advance for each week of classes

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 20

active teaching (practical)

auditory exercises: 25
laboratory exercises: 3
calculation tasks: 0
seminar works: 0
project design: 12
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 4
colloquium, with assessment: 6
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 45
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 15
final exam: 30
requirements to take the exam (number of points): 21

references

Refrigeration Systems

ID: MSc-0192
teaching professor: Коси Ф. Франц
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: thermal science engineering

goals

Achieving of competence and academic skills as well as methods for their acquisition. The development of creative abilities and practical skills which are essential to the profession. Objectives are concrete and achievable and in full accordance with the defined basic tasks and objectives of the study program.

learning outcomes

Student acquires subject-specific abilities that are essential for the quality of professional activities: analysis, synthesis and prediction of solutions and consequences; application of knowledge in practice; linking the basic knowledge in various fields with their application to solve specific problems.

theoretical teaching

Thermodynamic basis: Moist air, thermodynamic properties of moist air, Molier's "h-x" diagram, Important psychrometric processes, Dalton's and Lewis's Law of evaporation, Wet bulb temperature of moist air, Evaporation heat transfer calculation, Merkel's coefficient; Heat exchangers: NTU method, Heat exchanger characteristics; Characteristics of compressors; Condensers: Sizing of air-cooled, water-cooled and evaporative condensers; Evaporators: the process of refrigerant boiling, the processes on the cooled fluid side, Sizing of air cooling evaporators, Characteristics of evaporators; Analysis of complete vapour compression refrigeration systems.

practical teaching

Auditory training: Psychrometric processes, Evaporation heat transfer; prediction of the compressor characteristic, sizing of condensers (air-cooled, water-cooled and evaporative), sizing of evaporators, evaporator characteristic calculation; Analysis of complete vapour compression refrigeration systems; Laboratory exercise: demonstration of the installation in an industrial refrigeration plant; Design project of refrigeration system: work in groups of 5 students (for a particular object and refrigerant), calculation and selection of elements of refrigeration plants, PI diagram of refrigeration plant.

prerequisite

required exams passed: Refrigeration Equipment

learning resources

Textbook: M. Markoski: Air-conditioning, Mechanical Engineering, 2006,
"Handouts" which will be available in advance for each week of classes

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 10
laboratory exercises: 5
calculation tasks: 0
seminar works: 0
project design: 15
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 5
colloquium, with assessment: 5
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 30
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 20
final exam: 50
requirements to take the exam (number of points): 21

references

Steam Boiler processing

ID: MSc-0176
teaching professor: Живановић В. Титослав
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: thermal science engineering

goals

Reaching the competence and academic skills and methods for it's acquiring. Developing creative capabilities and mastering the specific practical skills. Goals determine the specific results which should be achieved within the subject. Goals also represent basis for control of the achieved results. Activities in this subject are in accordance with basic tasks and goals of the study program.

learning outcomes

Student acquires specific capabilities which are needed for carrying out professional activities: analysis, synthesis and anticipating the results and consequences; use of knowledge from different areas for solving specific problems.

theoretical teaching

Thermal calculation of the steam boiler heating surfaces - calculation of furnace, calculation of half-radiation and convection heating surfaces; Mill processes (coal dust characteristics, heat and material balance of mill drying process, mill control diagram);
Aerodynamic of the air and flue gas tract (balanced draft boiler, forced draft boiler and natural draft boiler); Hydrodynamics of steam boiler (hydrodynamics of water heater, evaporator and superheater); Steam boiler strength calculation; Corrosion, wear, defilement and cleaning of steam boiler elements.

practical teaching

Auditory exercises consist of demonstration exercises (Classification and construction of steam boilers with appropriate heating surfaces, auxiliary devices and equipment); Guidelines for preparation of the project - Based on information (obtained and calculated) in the project from subject Steam boiler elements and equipment, it is necessary to develop thermal calculations for given industrial steam boiler. In this project it is necessary to perform thermal calculation and dimensioning of the following heating surface - furnace (radiation evaporator), convective evaporator, steam superheaters, water and air heaters. After dimensioning the steam boiler heating surfaces, it's necessary to make the steam boiler drawing in three sections.

prerequisite

Necessary condition: Bachelor's degree;
Preferred passed exam: Steam boilers elements and equipments

learning resources

Books: Lj. Brkic, T. Zivanovic, D. Tucakovic: Steam Boilers, Faculty of Mechanical Engineering, Belgrade, 2010, (In Serbian); Lj. Brkic, T. Zivanovic, D. Tucakovic: Steam Boilers Thermal Calculation, Faculty of Mechanical Engineering, Belgrade, 2010, (In Serbian); handouts which will be at student's disposal a week in advance

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 6
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 14
consultations: 0
discussion and workshop: 10
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 4
colloquium, with assessment: 6
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 30
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 30
final exam: 40
requirements to take the exam (number of points): 30

references

Lj. Brkic, T. Zivanovic, D. Tucakovic: Steam Boilers, Faculty of Mechanical Engineering, Belgrade, 2010, (In Serbian)
Lj. Brkic, T. Zivanovic, D. Tucakovic: Steam Boilers Thermal Calculation, Faculty of Mechanical Engineering, Belgrade, 2010, (In Serbian)

Steam Boilers elements and equipments

ID: MSc-0269
teaching professor: Живановић В. Титослав
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: thermal science engineering

goals

Reaching the competence and academic skills and methods for it's acquiring. Developing creative capabilities and mastering the specific practical skills. Goals determine the specific results which should be achieved within the subject. Goals also represent basis for control of the achieved results. Activities in this subject are in accordance with basic tasks and goals of the study program.

learning outcomes

Student acquires specific capabilities which are needed for carrying out professional activities: analysis, synthesis and anticipating the results and consequences; use of knowledge from different areas for solving specific problems.

theoretical teaching

Introduction; Solid fuels; Combustion material balance; Determination of excess air; Regulating the temperature of superheated steam - (Inherent regulation; Flue gas regulation; Steam regulation); Regulating the temperature of reheated steam; Apparatus for combustion of the opposite scheme - flat grate stoker; Apparatus for combustion of the cross scheme - chain and inclined grate stoker; Coal dust preparation systems; Devices for storage and transportation of coal; Mill constructions; Coal dust separators; Coal dust classifiers; Coal dust burners

practical teaching

Auditory exercises consist of demonstration exercises (Classification and construction of steam boilers with appropriate heating surfaces, auxiliary devices and equipment); Steam boiler heat balance; Working project - Workng principle of industrial steam boilers; Determining the losses, efficiency and fuel consumption of the given steam boiler; Furnace dimensioning; Heat and material balance of steam boiler heating surfaces; Making of the boiler draft.

prerequisite

Necessary condition: Bachelor's degree ;
Preferred passed exam: steam boiler basics

learning resources

Books: Lj. Brkic, T. Zivanovic, D. Tucakovic: Steam Boilers, Faculty of Mechanical Engineering, Belgrade, 2010, (In Serbian); Lj. Brkic, T. Zivanovic, D. Tucakovic: Steam Boilers Thermal Calculation, Faculty of Mechanical Engineering, Belgrade, 2010, (In Serbian); handouts which will be at student's disposal a week in advance

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 12
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 8
consultations: 0
discussion and workshop: 10
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 4
colloquium, with assessment: 6
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 30
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 30
final exam: 40
requirements to take the exam (number of points): 30

references

Lj. Brkic, T. Zivanovic, D. Tucakovic: Steam Boilers, Faculty of Mechanical Engineering, Belgrade, 2010, (In Serbian)
Lj. Brkic, T. Zivanovic, D. Tucakovic: Steam Boilers Thermal Calculation, Faculty of Mechanical Engineering, Belgrade, 2010, (In Serbian)

Thermal Power Plants and Heat Plants

ID: MSc-0110
teaching professor: Живановић В. Титослав
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: thermal science engineering

goals

Reaching the competence and academic skills and methods for it's acquiring. Developing creative capabilities and mastering the specific practical skills. Goals determine the specific results which should be achieved within the subject. Goals also represent basis for control of the achieved results. Activities in this subject are in accordance with basic tasks and goals of the study program.

learning outcomes

Student acquires specific capabilities which are needed for carrying out professional activities: analysis, synthesis and anticipating the results and consequences; use of knowledge from different areas for solving specific problems.

theoretical teaching

Consumption of electrical and thermal energy; division of thermal power plants and technological scheme of thermal power plants; Efficiency and heat balance of condensation thermal power plant; Thermal efficiency and energy indicators of heating power stations; Steam parameters and reheating; Regenerative feed water heating; loss of steam, water and condensate and their fill; Power plant water supply; Transportation and storage of fuel in power plants; Transportation of slag and fly ash in thermal power plants; Filtration and drainage of flue gases into the atmosphere; Location and general plan for power plants;

practical teaching

Auditory exercises consist from demonstration exercises (Presentation and explanation of thermal power plant schemes; Representation and explanation of the power plant elements; Steam parameters of thermal power plants and reheating; Regenerative heating of condensate and feed water; The main operating facilities of domestic power plants; Displaying general plans for local power stations; Problems of exploitation of power plants); Instructions for making calculation task - Main features of the power plant block; Instructions for preparation of the paper - Elements of the power plant main facilities.

prerequisite

Necessary condition: Bachelor's degree;
Preferred passed exam: Steam boilers elements and equipments and Steam boiler processing

learning resources

Books: Lj. Brkic, T. Zivanovic, D. Tucakovic: Steam Boilers, Faculty of Mechanical Engineering, Belgrade, 2010, (In Serbian); Lj. Brkic, T. Zivanovic, D. Tucakovic: Steam Boilers Thermal Calculation, Faculty of Mechanical Engineering, Belgrade, 2010, (In Serbian); handouts which will be at student's disposal a week in advance

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 6
laboratory exercises: 0
calculation tasks: 6
seminar works: 6
project design: 0
consultations: 2
discussion and workshop: 10
research: 0

knowledge checks

check and assessment of calculation tasks: 2
check and assessment of lab reports: 0
check and assessment of seminar works: 2
check and assessment of projects: 0
colloquium, with assessment: 6
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 30
laboratory exercises: 0
calculation tasks: 15
seminar works: 15
project design: 0
final exam: 40
requirements to take the exam (number of points): 30

references

Lj. Brkic, T. Zivanovic, D. Tucakovic: Steam Boilers, Faculty of Mechanical Engineering, Belgrade, 2010, (In Serbian)
Lj. Brkic, T. Zivanovic, D. Tucakovic: Steam Boilers Thermal Calculation, Faculty of Mechanical Engineering, Belgrade, 2010, (In Serbian)

Ventilating and Air Conditioning Systems

ID: MSc-0137
teaching professor: Живковић Д. Бранислав
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: thermal science engineering

goals

Getting knowledge and skills in air conditioning - various central air conditioning systems; mastering methods for calculating air ducts, choosing elements for intake and extract of air, and using those methods in air conditioning project design.

learning outcomes

Student acquires specific abilities and knowledge in air conditioning: he knows various central air conditioning system, methods of air ducts calculations and he can use it in practice. Student links basic knowledge and apply it in solving concrete problems in air conditioning.

theoretical teaching

Air distributing elements; duct calculation methods; air distribution; airflow range; air inlet and extract position; air conditioning systems - classification; central single-duct low pressure system with constant air volume, zone air conditioning systems; high pressure air conditioning systems: with constant and variable airflow rate; air to water air conditioning systems; induction unit; two pipes systems change over and no change over; three-pipe and four-pipe systems; hydronic systems with fan coil units; combination with ventilating systems, local air conditioning systems; compact and split systems; energy efficiency of ventilation and air conditioning systems.

practical teaching

Auditory is composed of more sections, in order to complete project design. Design and regulating air conditioning systems, calculating energy consumption and using waste heat. Laboratory consists of measuring airflow in ducts and distributive elements, regulating air conditioning systems, measuring airflow range and intermediate operating mode. Visit to Thermal science exhibition in HVAC congress or to factory for air conditioning equipment is planned.

prerequisite

In order to attend subject it is required to pass the exam: Fundamentals of Air Conditioning.

learning resources

Handouts

B. Todorovic, Air conditioning

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 10
laboratory exercises: 5
calculation tasks: 0
seminar works: 0
project design: 15
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 5
colloquium, with assessment: 5
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 30
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 20
final exam: 50
requirements to take the exam (number of points): 21

references

ASHRAE Handbook of Fundamentals, Atlanta, Georgia, 2009
Recknagel, Sprenger, Schramek, Ceperkovic: Heating and Air Conditioning, Interklima, Vrnjacka Banja, 2002

thermomechanics

Heat and Mass Transfer
Heat transfer
Thermodynamics M

Heat and Mass Transfer

ID: MSc-0350
teaching professor: Саљников В. Александар
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: thermomechanics

goals

Students shall gain knowledge in heat and mass transfer scientific discipline that is the basis for design of devices and plants in process engineering, thermal engineering and power engineering. Students shall learn steady state and transient heat conduction, forced and free heat convection and - heat convection in condensation and boiling; as well and radiation heat transfer, modern methods of heat exchangers design and - modes of mass (substance) transfer.

learning outcomes

After completing the course, passed quizzes and tests and successfully completed exam, students will be able to independently perform thermal calculations of simpler thermal engineering plants and unitary devices. Result of the course is also acquiring basic knowledge that enable active participation in related theoretical and applied courses.

theoretical teaching

1. Heat conduction - basic concepts, Fourier law, Fourier differential equation; steady state conduction; rods and fins; transient conduction; numerical and other methods.
2. Heat convection - conduction and advection; similarity theory, forced and free convection; and in boiling and condensation.
3. Heat exchangers - mean logarithmic temperature difference method; method of exchanger efficiency and number of transfer units (ε-NTU method).
4. Radiation heat transfer - basic mechanisms, wave and quantum theory, fundamental laws; radiation exchange between 2 surfaces with intermediate two atomic (thermally transparent) gas or mixture of triatomic CO_2 and H_2O i.e. the "greenhouse effect" gases.
5. Mass (substance) transfer - diffusion, concentration gradient, diffusivity and Fick's law. Convection of mass and non dimensional criteria.

practical teaching

1. Numerical exercises - steady state conduction; bodies with inside heat sources, critical thickness of pipe insulation, rods and fins. Transient heat conduction; lumped capacitance method semi infinite solid; numerical methods.
2. Numerical exercises: forced and natural convection; determining Nusselt number and heat convection coefficient, boiling and condensation convective heat transfer.
3. Numerical exercises: heat exchangers - mean logarithmic temperature difference method; method of heat exchanger efficiency and number of heat transfer units (ε-NTU method);
4. Numerical exercises: radiation exchange between 2 surfaces with intermediate; A) two atomic (thermally transparent) gas; B) mixture of CO_2 and H_2O i.e. the "greenhouse effect" gases.
5. Numerical exercises - mass diffusion, concentration gradient, diffusivity and Fick's law; convection of mass and non-dimensional criteria.

prerequisite

Necessary: Physics, Thermodynamics B
Desirable: Hydraulics and pneumatics (Fluid mechanics)

learning resources

1. Handouts for heat and mass transfer, site of Mašinski fakultet, Beograd.
2. Milinčić, D.: Heat transfer, Mašinski fakultet, Beograd, 1989.
3. Kozić, Đ., Gojak, M., Komatina, M., Antonijević, D., Saljnikov, A.: Exercises in heat transfer, Mašinski fakultet, Beograd, 2002.
4. Milinčić, D., Vasiljević, B., Đorđević, R.: Problems in heat transfer, Mašinski fakultet, Beograd, 1991.
5. Kozić, Đ., Vasiljević, B., Bekavac, V.: Handbook for thermodynamics, Mašinski fakultet, Beograd, 2006.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 20
laboratory exercises: 0
calculation tasks: 5
seminar works: 5
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 5
test, with assessment: 5
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 60
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 40
requirements to take the exam (number of points): 20

references

F.P. Incropera, D.P. deWitt: Fundamentals of Heat Transfer, John Wiley & Sons, 1980.
J.P. Holman: Heat Transfer, McGraw Hill, 2002

Heat transfer

ID: MSc-0478
teaching professor: Бањац Ј. Милош
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: thermomechanics

goals

Through the introducing with physical basis of heat transfer, students should gain a basic theoretical, and through the practical examples and professional knowledges and skills which will enable them to independently identify and solved the basic heat transfer problems that engineers of thermo-technique, thermo-energetic and processes engereering are faced.

learning outcomes

Creating skills for recognizing, understanding and analysing of problems and gaining knowledges and skills necessary to carry out the usual heat transfer calculations and design certain elements of different energy facilities equipment – facilities for heating, cooling, food and others technology. These gains skills will be a necessary base of knowledge for active attend lectures on other scientific- professional and professional-application subjects.

theoretical teaching

1. Basic terms and principles
2. Thermal Conduction - steady heat conducting
3. Thermal Conduction - transient heat conducting
4. Heat transfer by convection – forced convection, natural convectin
5. Boiling and condensation
6. Heat exchanger
7. Thermal radiation

practical teaching

1. Workshop and discussion dedicated to basic terms and principles of heat transfer
2. Problems and examples in connection with steady heat conduction
3. Problems and examples in connection with transient heat conduction
4. Problems and examples in connection with heat convection
5. Problems and examples in connection with processes of boiling and processes of condensation
6. Problems and examples in connection with heat exchangers
7. Problems and examples in connection with thermal radiation
8. Workshop and discussion dedicated to processes of
a.steady heat convection,
b.steady heat convection in processes of boiling and processes of condensation
c.steady heat transer in heat exchangers
9. Laboratory exercise: Demonstration of "heat" pipe
10.Workshop and discussion dedicated to problems of thermal radiation

prerequisite

Passed exams: Physics and measurements and Thermodynamics B
Desirable, passed exams: Applied Thermodynamics and Fluid Mechanics B

learning resources

1. Milincic, D., Vasiljevic, B., Djordjevic, R.: Heat Transfer Problems, Faculty of Mechanical Engineering of University of Belgrade, Belgrade, 1991.
2. Milincic, D.: Heat transfer, Naucna knjiga, Belgrade, 1989.
3. Handouts
4. Incropera, F., DeWit, D., Bergman, T, Lavine, A: Introduction to Heat Transfer, Wiley, 5th edition, 912 pages, 2006.
5. Cengel, Y.: Heat Transfer A Practical Approach, McGraw - Hill; 2nd edition 1024 pages, 2003.
6. Cengel, Y., Ghajar, A: Heat and Mass Transfer: Fundamentals and Applications + EES DVD for Heat and Mass Transfer, McGraw-Hill Science/Engineering/Math; 4 edition, 924 pages, 2010.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 28
laboratory exercises: 1
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 2
discussion and workshop: 6
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 6
test, with assessment: 2
final exam: 0

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 60
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 40
requirements to take the exam (number of points): 25

references

Milincic, D., Vasiljevic, B., Djordjevic, R.: Heat Transfer Problems, Faculty of Mechanical Engineering of University of Belgrade, Belgrade, 1991.
Milincic, D.: Heat transfer, Naucna knjiga, Belgrade, 1989.
Incropera, F., DeWit, D., Bergman, T, Lavine, A: Introduction to Heat Transfer, Wiley, 5th edition, 912 pages, 2006.
Cengel, Y.: Heat Transfer A Practical Approach, McGraw - Hill; 2nd edition 1024 pages, 2003.
Cengel, Y., Ghajar, A: Heat and Mass Transfer: Fundamentals and Applications + EES DVD for Heat and Mass Transfer, McGraw-Hill Science/Engineering/Math; 4 edition, 924 pages, 2010.

Thermodynamics M

ID: MSc-0202
teaching professor: Коматина С. Мирко
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written+oral
parent department: thermomechanics

goals

Student should gain knowledge in thermodynamics and thermal devices and plants that are present in process engineering, thermal engineering and power engineering. Through practical and theoretical education should understand from thermodynamic aspect the transformation of thermal energy into mechanical work and gain physical fundamentals on phenomena that go on in steam turbine, gas turbine and refrigeration devices as well as in plants for drying various materials and air conditioning of corresponding spaces.

learning outcomes

After completing the course, including quizzes and tests and successfully passed exam, students shall be ready to independently perform thermodynamic calculations of simpler thermal plants and particular devices. The result of this course is also acquiring fundamental knowledge that serves as the basis for active participation in other theoretical and applicative courses.

theoretical teaching

1.First law of thermodynamics for open thermomechanic system. Mass balance. Energy balance.
2.Second law of thermodynamics for open thermomechanic systems.
3.Exergy of closed and open thermomechanic systems.
4.Thermodynamic analysis of operation of basic thermomechanic devices and plants.
5.Thermodynamics of complex systems, outflow.
6.Humid air - devices and plants that operate with humid air.

practical teaching

1.Numerical exercises on First law of thermodynamics for open thermomechanic system.
2.Numerical exercises on Second law of thermodynamics for open thermomechanic systems.
3.Numerical exercises on exergy of closed and open thermomechanic systems.
4.Numerical exercises on thermodynamic analysis of operation of thermomechanic devices and plants.
5.Numerical exercises on thermodynamics of complex systems.
6.Numerical exercises on processes, devices and plants that operate with humid air.

prerequisite

Necessary: Physics, Thermodynamics B

learning resources

1. Milinčić, D., Voronjec, D.: Thermodynamics, Mašinski fakultet, Beograd, 1990
2. Kozić, Đ.: Thermodynamics, Mašinski fakultet, Beograd, 2007
3. Vasiljević, B., Banjac, M.: Map for thermodynamics, Mašinski fakultet, Beograd, 2002
4. Kozić, Đ., Vasiljević, B., Bekavac, V.: Handbook for thermodynamics, Beograd, 2006

5. Handouts for Thermodynamics M, site of Mašinski fakultet, Beograd.

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 25
laboratory exercises: 0
calculation tasks: 5
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 4
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 3
test, with assessment: 3
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 60
laboratory exercises: 0
calculation tasks: 0
seminar works: 5
project design: 0
final exam: 35
requirements to take the exam (number of points): 20

references

Y.A.Cengel, M.A.Boles. Thermodynamics. An Engineering Approach. 3rd Edition, McGraw Hill, 1998
A. Bejan: Advanced Engineering Thermodynamics, John Wiley & Sons, 1988

weapon systems

Aerodynamics of Projectiles
Artillery Weapons Design
Automatic Weapons
Fire Control Systems
Flight Dynamics of Projectiles
Interior Ballistics
Launching equipment
Launching Theory
Missile Aerodynamics
Missile Aerodynamics
Missile design
Missile Guidance and Control
Missile Guidance and Control
Missile Propulsion
Optical devices and optoelectronics
Physics of Explosive Processes
Professional Practice M - SIN
Projectile Design
Rocket Propulsion
Terminal Ballistics

Aerodynamics of Projectiles

ID: MSc-0687
teaching professor: Милиновић П. Момчило
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 2
final exam: written
parent department: weapon systems

goals

Introducing students to the fundamentals of aerodynamic calculations. Introducing students to the fundamentals of structure and implementation of programs for the calculation of missile aerodynamics. Introducing to the experimental methods in aerodynamics.

learning outcomes

The student is able to work independently on the calculation of aerodynamic characteristics of guided and unguided projectiles. Student is qualified for experimental work in the field of aerodynamic test methods.

theoretical teaching

The basic methods of aerodynamic calculation (classification of aerodynamic calculation methods; introduction to the method of breaking up into the components; aerodynamic testing).
Aerodynamic characteristics of the fuselage (the fuselage geometry, methods of calculation of aerodynamic forces).
Aerodynamic characteristics of the lifting surface (lifting surface geometry, aerodynamics calculation method of lifting surfaces)
Aerodynamic interference (wing-fuselage interference, interference of wing-wing)
Software packages for aerodynamic missiles (basic structure; standard software packages).
Aerodynamic design (methods of aerodynamic design; the choice of parameters; examples of computer calculations using the package DATCOM).

practical teaching

The basic methods of aerodynamic calculation (Introduction to the method of breaking up into components).
Aerodynamic characteristics of the fuselage (Examples of calculations of fuselage aerodynamics).
Aerodynamic characteristics of the lifting surfaces (Examples of calculations of aerodynamics bearing surfaces).
Aerodynamic Interference (Examples of calculations of aerodynamic interference).
Software packages for missile aerodynamics (Elaboration of an example calculations using the computer package DATCOM).
Aerodynamic design (Elaboration of design examples using the computer package DATCOM).

prerequisite

learning resources

1. Blagojevic, Dj.: Aerodynamics of projectiles - lectures, Belgrade, 2010.
2. Jankovic, S.: Aerodynamics of projectiles, Faculty of Mechanical Engineering, Belgrade, 1979.

number of hours

total number of hours: 30

active teaching (theoretical)

lectures: 8

active teaching (practical)

auditory exercises: 8
laboratory exercises: 0
calculation tasks: 4
seminar works: 4
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 2
check and assessment of projects: 0
colloquium, with assessment: 2
test, with assessment: 0
final exam: 2

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 20
laboratory exercises: 0
calculation tasks: 0
seminar works: 20
project design: 0
final exam: 50
requirements to take the exam (number of points): 25

references

R. Nielsen, Missile Aerodynamics, New York, 2001.

Artillery Weapons Design

ID: MSc-0101
teaching professor: Мицковић М. Дејан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 4
final exam: written
parent department: weapon systems

goals

Detailed analysis of design solutions for individual elements of artillery weapons. Detailed study of design methodologies for the main structural elements of weapons. Practical implementation of calculations for basic structural elements of artillery weapon through the realisation of projects.

learning outcomes

Mastering the calculation of basic parameters that characterize the function of individual pieces of artillery systems. Acquiring the ability of students to create their own software tool for the design of individual structural elements of artillery weapons. Qualifications for the design of the main structural elements of artillery systems.

theoretical teaching

Behaviour of the artillery weapon during firing. Design of muzzle brakes. Design of recoil mechanisms (recuperator, hydraulic recoil brake, hydraulic counterrecoil brake and fluid compensator). Design of devices and mechanisms of artillery mounts (cradle, top carriage, bottom carriage arms and equilibrators). Organization of surface and bore of gun barrel. Design of simple monoblock tube. Deformations and stresses in the walls of the doublelayer tube in rest state and when firing. Design of reinforced doublelayer tube. Basic concepts of autofrettage. Design of monoblock tube with autofrettage. The main types of breechblocks and their characteristics. Design of breechblock mechanism elements for: obturation, triggering and firing, opening, case ejection and closing. Characteristics and functions of breech rings. Design of breech rings.

practical teaching

Calculation of gun stability during firing. Design of muzzle brakes. Design of recoil mechanisms (recuperator, hydraulic recoil brake, hydraulic counterrecoil brake and fluid compensator). Design of devices and mechanisms of artillery mounts (cradle, top carriage, bottom carriage arms and equilibrators). Design of simple monoblock tube. Deformations and stresses in the walls of the doublelayer tube in rest state and when firing. Design of reinforced doublelayer tube. Basic concepts of autofrettage. Design of monoblock tube with autofrettage. Calculation of breechblock mechanism elements for: obturation, triggering and firing, opening, case ejection and closing. Design of breech rings.

prerequisite

Without specific conditions for attending the subject. Desirable - passed the exam in the subject Classical Armament Design.

learning resources

1. Micković D.: Design of Artillery Weapons - Handouts

2. Obrenović R.: Construction of Artillery Weapons, TŠC KoV JNA, Zagreb, 1975

number of hours

total number of hours: 45

active teaching (theoretical)

lectures: 18

active teaching (practical)

auditory exercises: 6
laboratory exercises: 0
calculation tasks: 2
seminar works: 0
project design: 8
consultations: 2
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 2
colloquium, with assessment: 2
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 30
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 30
final exam: 30
requirements to take the exam (number of points): 35

references

Automatic Weapons

ID: MSc-0181
teaching professor: Мицковић М. Дејан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 2
final exam: written
parent department: weapon systems

goals

Introducing of students to the basic elements of the automatic weapons. Formation of the system of differential equations that describe the movement of elements of the mechanisms of automatic weapons during the firing cycle. The study of methods for solving these differential equations. Preliminary design of various systems of automatic weapons.

learning outcomes

Mastering the calculation of basic parameters that characterize the function of various systems of automatic weapons. Acquiring the ability of students to create their own software tool for preliminary design of an automatic weapon. Qualifications for the design of individual elements of the automatic systems and optimisation of function of different types of automatic weapons.

theoretical teaching

Forces acting on the parts of an automatic weapon. Types of automatic weapons. Bolt locking systems and mechanical safety. Analysis of the cartridge case functions during firing. Analysis of differential equations of motion of elements in the mechanisms of automatic weapons with non-movable and movable receiver and methods for solving them. Characteristics of the movement of members of automatic weapon mechanisms. Determination of the transfer ratio and coefficient of efficiency of mechanisms that are used in the construction of an automatic weapon. Strikes in the mechanisms of automatic weapons. Movement of parts of automatics under the action of springs. Preliminary design of an automatic weapon: blow back operation systems (simple blow back, blow back with advanced primer ignition, delayed blow back, blow back with a locked breech), recoil operated systems (long recoil, short recoil), gas operation systems (long stroke pistons, short stroke pistons, direct gas action).

practical teaching

Calculation of forces acting on elements of an automatic weapon. Bolt locking systems and mechanical safety. Analysis of the cartridge case functions during firing. Methods of solving differential equations of motion of elements in the mechanisms of automatic weapons with non-movable and movable receiver.Characteristics of the movement of members of automatic weapon mechanisms. Determination of the transfer ratio and coefficient of efficiency of mechanisms that are used in the construction of an automatic weapon. Strikes in the mechanisms of automatic weapons. Movement of parts of automatics under the action of springs. Preliminary design of an automatic weapon: blow back operation systems (simple blow back, blow back with advanced primer ignition, delayed blow back, blow back with a locked breech), recoil operated systems (long recoil, short recoil), gas operation systems (long stroke pistons, short stroke pistons, direct gas action).

prerequisite

Desirable - passed the exam in the subject Classical Armament Design.

learning resources

1. Micković D.:Handouts - Automatic Weapons
2. Vasiljević M.: Automatic Weapons, TŠC KoV JNA, Zagreb, 1970

number of hours

total number of hours: 30

active teaching (theoretical)

lectures: 12

active teaching (practical)

auditory exercises: 7
laboratory exercises: 0
calculation tasks: 0
seminar works: 2
project design: 0
consultations: 3
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 1
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 30
laboratory exercises: 0
calculation tasks: 0
seminar works: 30
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

Automatic Weapons - Engineering Design Handbook, US Army Materiel Command Pamphlet 706-260, 1970

Fire Control Systems

ID: MSc-0111
teaching professor: Милиновић П. Момчило
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 2
final exam: oral
parent department: weapon systems

goals

Goal of subject is orientated to the student knowledge about basic technologies integrated in the battle that provides precise engagement and reliable shooting of target by direct, indirect or other type of weapon fire. Modern systems employed and design by the basic knowledge about LOS, NLOS, and other shooting elements and principles
understand sensor principles, automatic devices and software proceedings, based on ballistic shooting elements. Modern navigation and position principles of weapon fire
represented by fundamental vectoral battle mechanics, of platforms motion, targets and projectiles flight in FCS composition models. Processes are represented by artillery, AD, BMD, and armored vehicles battle mechanics and platforms and units integrated systems.

learning outcomes

Student is trained and educated to solve individual employment of weapon and their integrations of performances with other non weapon helping defense equipment and battle functions. Those understand shooting functions precision positioning and errors estimation, preparing weapon for selected target mission, and ballistics and flight mechanics estimation for optimal target shooting. Also student achieve basic knowledge for Command information battle technology and weapon fire precision strike technology. Software, autoimmunization and mechatronics sensor integration, in the battlefield mechanics of unsteady state vectoral proposals provides FCS software and hardware knowledge, for weapon designers.

theoretical teaching

1. Ballistic trajectories in shooting principles for LOS and NLOS projectiles and types of weapon fire.
2. Conventional indirect fire artillery shooting and FCS.
3. Shooting artillery of armored vehicles in motion and direct fire autoimmunization stabilization and errors estimations. Devices and equipment of weapon stabilization and equipment for FCS
4. Air defense gun systems and AD combat platforms and AD responsibilities areas
5 Sensors, tracking targets equipment, sighting, automatic optoelectronics, and IR technology laser range finders and navigation GIS and GPS systems and errors performances and analyzes.

practical teaching

1. Examples of trajectories and corresponding tactical weapon type.
2. Armored vehicles and tank weapons stabilization and shooting FCS integration
3. Automatic control principles for tracking and shooting for air defense platforms and systems /gun and missiles
1.4. UAV and navigating principles of GIS and GPS precision strike on the target., and new concepts of C2I, C3I, C4I, C4ISTAR, in command and control FCS navigation

prerequisite

learning resources

M.Milinovic: Contemporary problems of fire control systems in AD defense. University of Belgrade Faculty of ME, Belgrade, monograph.
M.Milinovic: Fire control system dynamics (serb), University of Belgrade Faculty of ME, Belgrade, textbook.

number of hours

total number of hours: 30

active teaching (theoretical)

lectures: 12

active teaching (practical)

auditory exercises: 12
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 1
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 30
laboratory exercises: 0
calculation tasks: 0
seminar works: 30
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

Eugene L. Fleeman, Tactical Missile Design, 2001 AIAA, USA
Robert L. McCoy, Modern Exterior Ballistics, 1999 AIAA, USA

Flight Dynamics of Projectiles

ID: MSc-0688
teaching professor: Елек М. Предраг
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 4
final exam: written
parent department: weapon systems

goals

Introducing students to the fundamentals of calculation and modeling of flight dynamics. Introducing students to the fundamentals of structure and implementation of programs for modeling of flight dynamics. Introduction to experimental methods of flight testing.

learning outcomes

The student is able to work independently on calculation and modeling of flight dynamics of guided and unguided projectiles. Student is qualified for experimental work in the field of flight tests.

theoretical teaching

Stability of aerodynamically stabilized projectiles (static stability, dynamic stability, oscillations and resonance of rolling)
Stability of gyro-stabilized projectile (static stability, dynamic stability)
Controlability of guided missiles (methods of control; roll stabilization, control of normal force)
Fundamentals of modeling of projectile flight dynamics (Introduction to modeling, modeling with 3 and 6 degrees of freedom)
Unguided missiles modeling (introduction to the modeling of unguided missiles)
Guided missiles modeling (introduction to the modeling of guided missiles)

practical teaching

Stability of aerodynamically stabilized projectiles (examples of calculations)
Stability of gyro-stabilized projectile (examples of calculations)
Controlability of guided missiles (examples of calculations)
Fundamentals of modeling of projectile flight dynamics (6DOF modeling packages and program CADAC)
Unguided missiles modeling (modeling examples)
Guided missiles modeling (modeling examples)

prerequisite

learning resources

1. Blagojevic, Dj.: Flight Dynamics of Projectiles, Belgrade, 2004. (in Serbian)
2. Zipfel, P.H.: Modeling and Simulation of Aerospace Vehicle Dynamics, New York, 2007.

number of hours

total number of hours: 45

active teaching (theoretical)

lectures: 18

active teaching (practical)

auditory exercises: 6
laboratory exercises: 0
calculation tasks: 6
seminar works: 0
project design: 6
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 3
colloquium, with assessment: 3
test, with assessment: 0
final exam: 3

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 20
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 20
final exam: 50
requirements to take the exam (number of points): 25

references

McCoy, R.L.: Modern Exterior Ballistics, Shiffer Publishing, 2012.

Interior Ballistics

ID: MSc-0184
teaching professor: Јарамаз С. Слободан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 4
final exam: written
parent department: weapon systems

goals

Study of methods of solving the basic task of interior ballistics and ballistic design. The study of the basic characteristics of special types of weapons. Consideration of methodology of interior ballistic tests.

learning outcomes

Mastering the calculation of direct and indirect task of interior ballistics of various types of weapons, and the methodology of interior ballistic tests.

theoretical teaching

Introduction to interior ballistics.
Gun propellants and their characteristics.
Basic processes and laws during firing.
Solution of the basic task of interior ballistics (Task statement. The analytical method of solving. Propellant gas temperature calculation. Tabular method of solving the basic task of interior ballistics).
Ballistic design.
The solution of the task of internal ballistics for the combined (howitzer) charge.
Interior ballistics of recoilless weapons.
Interior ballistics of mortars.
The introduction of interior ballistic corrections (Ermolaev method).
Interior ballistic tests (objective, classification and measuring parameters). Interior ballistic test preparation. Pressure measurement. Measurement of gun muzzle velocity. Measuring of recoil system impulse.

practical teaching

Production of gunpowder.
Basic processes and laws during firing.
Solution of the basic task of interior ballistics (Task statement. The analytical method of solving. Propellant gas temperature calculation. Tabular method of solving the basic task of interior ballistics).
Interior ballistic design (Task of gun tube design. Interior ballistic characteristic of weapons. General dependence of structural tube characteristics on charge conditions. Directive diagram and its analysis).
The solution of the task of interior ballistics for the combined (howitzer) charge.
Introduction of interior ballistic corrections (Ermolaev method).

prerequisite

Passed exams (preferred): Thermodynamics B, Fundamentals of Projectiles Propulsion, Physics of Explosive Processes

learning resources

1. Jaramaz, S, Mickovic, D.: Interior ballistics, Faculty of Mechanical Engineering, Belgrade, 2002.
2. Interior ballistic design tables
3. Correctional coefficients tables

number of hours

total number of hours: 45

active teaching (theoretical)

lectures: 18

active teaching (practical)

auditory exercises: 4
laboratory exercises: 0
calculation tasks: 4
seminar works: 0
project design: 8
consultations: 2
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 2
colloquium, with assessment: 2
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 30
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 30
final exam: 30
requirements to take the exam (number of points): 35

references

Launching equipment

ID: MSc-0167
teaching professor: Милиновић П. Момчило
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 2
final exam: oral
parent department: weapon systems

goals

Goal of subject is to achieve student knowledge in two basic launcher equipment
Sub systems. Sub systems of equipment and devices for shooting and missiles positioning and launching, and subsystems of equipment and devices for other defense and military integrated functions available on the self-propelled weapon launcher.
Student through practical project research of concept and component integration
realize knowledge of software and hardware integration on the launcher and new technologies implementation on the self propelled or portable weapon missile launching
Systems.

learning outcomes

Student realizes skills and knowledge for individual integrating of launcher weapon,
their conceptual solutions and critical thinking and opinion about advantages for applied Systems and sub systems. Also launcher and its equipment is integrative design system test for knowledge of missile system design and defense functions. Student through practical selections of functions and its solutions gets knowledge of compromises in technology possibilities and threshold performances of practical use and its requirements.

theoretical teaching

1. Content of subsystems for MLRS, AT, AD, BM, launchers mechanisms integrated for missiles launching, and shooting, devices functional and equipment design.
2. Equipment for launching stability, energy supply and other conditions for functional and environmental uses of defense and functional missiles weapon technology.

practical teaching

1. Mass model of self propelled launcher of missiles .Principal solutions, and design art. Functional and defense properties capacities of launching and weapon performances of principal solutions
2. Kinematics and dynamics of launching mechanisms in joint work with system integration concept, elevation mechanism, stabilization mech. direction mechan., fire mech.and launching forces estimation.
3. Presentation of joint launcher project and its substitution with critical estimations of components, and technology.

prerequisite

learning resources

1. M. Milinovic: Basics of missiles and launchers design (serb), University of Belgrade Faculty of ME 2002., textbook
2. O. Vucurovic: Launchers design (serb), Belgrade University of Belgrade Faculty of ME 2002., monograph

number of hours

total number of hours: 30

active teaching (theoretical)

lectures: 12

active teaching (practical)

auditory exercises: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 12
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 1
colloquium, with assessment: 0
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 60
final exam: 30
requirements to take the exam (number of points): 35

references

O.Vucurovic The basic of launchers design , serb..Univers. of Belgrade , FME,Monograph, 2006.
Mmilinovic The basic of launchers design ,Univers. of Belgrade , eng , FME, layhandout 2000.

Launching Theory

ID: MSc-0195
teaching professor: Милиновић П. Момчило
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 2
final exam: oral
parent department: weapon systems

goals

The basic purpose of the subject is aimed to the student knowledge and skills of applied launching ballistic mechanics, gas dynamics of missiles starting motion, on-in, the launcher, and relative interactive motions of combat platforms and launcher .The basic theoretical goal is to introduce students with simplified models of disturbances mechanics and to calculate critical disturbance cases and their influences on the launching and final missile shooting errors. Also, goals are to evaluate global design performances of launcher by functional and exploitation combat loads, as the input for strain and stress integration analyses.

learning outcomes

Student achieve capabilities for individual analyzes, preliminary integration and syntheses of launching mechanics applied on the launcher mounted on the combat platform of any type or design. Accepted methodology provides student ability to calculate and verify missile weapon efficiency, by recognizing loads and disturbances composed in the missile weapon errors, caused by tube, rail or container launcher type and their processes, integrated and jointed with the combat platforms, of any vehicle or vessel.

theoretical teaching

1. Launching mechanics and disturbances of the missiles and rockets from the rail type of launcher
2. launching mechanics of the tube launcher and forced gas generating motion and disturbances
3. Vertical platforms launching, open and tubes closed and their critical disturbances
4. Ripple rocket launching and combat and launching recoil and attack forces, and launcher and vehicle stability and disturbances.

practical teaching

1. Solution examples for low spin fin stabilized and high spin gyro stabilized unguided
Rockets from the tube initial spin, and from the smooth barrel launchers.
2. Solutions of initial rocket flight and mathematical calculations of barrel length.
Active flight calculations for unguided rockets.
3. Vertical launching errors and stability calculations .Zero initial velocity launchers
4. Loads and disturbances calculation on the missiles launching of guided flight

prerequisite

learning resources

1. M. Milinovic: Basics of missiles and launchers design chapters from launcher designO. Вучуревић, Основи пројектовања ракета и лансера, Масински Факултет Београд 2003. (serb), University of Belgrade Faculty of ME 2002., textbook
2. O. Vucurovic: Launchers design (serb), Belgrade University of Belgrade Faculty of ME 2002., monograph

number of hours

total number of hours: 30

active teaching (theoretical)

lectures: 12

active teaching (practical)

auditory exercises: 12
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 1
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 30
laboratory exercises: 0
calculation tasks: 0
seminar works: 30
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

O.Vucurovic The basic of launchers design ,Univers. of Belgrade ,serb FME,Monograph, 2006.
M. MILINOVIC Launching theory , ,Univers. of Belgrade , engl, Univers. of Belgrade ,FME,layhandout, 2000.

Missile Aerodynamics

ID: MSc-0283
teaching professor: Благојевић Ђ. Ђорђе
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 2
final exam: oral
parent department: weapon systems

goals

Introducing students to the basics of aerodynamic calculations. Introducing students to the fundamentals of structure and implementation of programs for the calculation of missile aerodynamics. Introducing with the experimental methods in aerodynamics.

learning outcomes

The student is able to work independently on a calculation and aerodynamic characteristics of guided and unguided missiles. Student is qualified for experimental work in the field of aerodynamic test methods.

theoretical teaching

The basic methods of aerodynamic calculation (division of aerodynamic calculation methods, an introduction to the method of breaking up to the components, aerodynamic testing).
Aerodynamic characteristics of the fuselage (the fuselage geometry, methods of calculation of aerodynamic forces).
Aerodynamic characteristics of the bearing surface (bearing surface geometry, aerodynamics calculation method of bearing surfaces) .
Aerodynamic Interference (wing-fuselage interference, interference of wing-wing)
Software packages for aerodynamic missiles (base structure; standard software packages).
Aerodynamic design (methods of aerodynamic design, the choice of parameters; Develop examples of computer calculations using the package DATCOM; Development of examples of design on a computer using the package DATCOM)"

practical teaching

The basic methods of aerodynamic calculation (the fuselage geometry, methods of calculation of aerodynamic forces).
Aerodynamic characteristics of the bearing surface (bearing surface geometry, aerodynamics calculation method of bearing surfaces) .
Aerodynamic Interference
Software packages for aerodynamic missiles
Develop examples of computer calculations using the package DATCOM; Development of examples of design on a computer using the package DATCOM
Aerodynamic testing in the wind tunnel, aerodynamic flight test

prerequisite

none

learning resources

1. Djordje Blagojevic, Aerodynamics of missiles - manuscript, Belgrade
2. Slobodan Jankovic, Missile aerodynamics, Belgrade, 1979

number of hours

total number of hours: 30

active teaching (theoretical)

lectures: 12

active teaching (practical)

auditory exercises: 4
laboratory exercises: 0
calculation tasks: 8
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 1
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 20
laboratory exercises: 0
calculation tasks: 0
seminar works: 20
project design: 0
final exam: 50
requirements to take the exam (number of points): 25

references

R. Nielsen, Missile Aerodynamics, New York, 2001

Missile Aerodynamics

ID: MSc-0284
teaching professor: Благојевић Ђ. Ђорђе
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 4
final exam: oral
parent department: weapon systems

goals

Introduce students to the basics of calculation and modeling of flight dynamics. Introducing students to the fundamentals of structure and implementation of programs for modeling a flight dynamics. Introduction to experimental methods of flight testing.

learning outcomes

The student is able to work independently on a calculation and modeling of guided and unguided missiles. Student is qualified for experimental work in the field of flight test.

theoretical teaching

The stability of aerodynamically stabilized projectiles (static stability, dynamic stability, oscillations and resonance of rolling; assignments).
Stability of gyro-stabilized projectile (static stability, dynamic stability; assignments).
Controllability of guided missiles (management methods; roll stabilization, control normal force ; assignments).
Basics of flight dynamics modeling of projectile (Introduction to modeling, modeling with 3 and 6 degrees of freedom, 6DOF modeling packages and CADAC).
Unguided missiles Modeling (introduction to the modeling of unguided missiles, working out examples of modeling).
Modeling guided missiles (introduction to the modeling of guided missiles, working out examples of modeling)

practical teaching

The stability of aerodynamically stabilized projectiles (static stability, dynamic stability, oscillations and resonance of rolling; assignments).
Stability of gyro-stabilized projectile (static stability, dynamic stability; assignments).
Controllability of guided missiles (management methods; roll stabilization, control normal force ; assignments).
Basics of flight dynamics modeling of projectile (Introduction to modeling, modeling with 3 and 6 degrees of freedom, 6DOF modeling packages and CADAC).
Unguided missiles Modeling (introduction to the modeling of unguided missiles, working out examples of modeling).
Modeling guided missiles (introduction to the modeling of guided missiles, working out examples of modeling)

prerequisite

none

learning resources

1.Djordje Blagojević,Missile flight dynamics, Belgrade, 2004;
2. P. H. Zipfel, Modeling and Simulation of Aerospace Vehicle Dynamics, New York, 2007

number of hours

total number of hours: 45

active teaching (theoretical)

lectures: 18

active teaching (practical)

auditory exercises: 8
laboratory exercises: 0
calculation tasks: 10
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 2
check and assessment of projects: 0
colloquium, with assessment: 2
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 20
laboratory exercises: 0
calculation tasks: 0
seminar works: 20
project design: 0
final exam: 50
requirements to take the exam (number of points): 25

references

Missile design

ID: MSc-0112
teaching professor: Милиновић П. Момчило
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 4
final exam: oral
parent department: weapon systems

goals

Goal of subject is to achieve student in detail contents of missiles subsystems its integration and key performances of flight and terminal phase, functions. Goal of
knowledge's are directed on the technology roll and influences on the particular quality and quantity of missiles performances .Missile is considered as the flight vehicle and ammunition for the different payload purposes and defense missions .Student developing detailed skills and knowledge for design, analyzes, syntheses of missiles and rockets and about its advanced technology applications on the component design its research and methodology of calculations and development.

learning outcomes

Student achieve level of individual designer of tactical missiles and other jobs and purposes of missile syntheses .Also, student is accomplished for the analyzes and syntheses of all levels and types in the missile and ammunition rocket technologies by tools of applied mechanics and software analyzes of integrative rocket and missile technologies and performances .Parametric composition of missile flight mechanics, special ballistics and rocket propulsion propellants performances and other interdisciplinary integration selection and estimations, is comprehension output of subject

theoretical teaching

1. Mmissiles and rockets as the ammunition or as the combat flight platform
2. Mass model, ranges and performances, defense performances of different missile types
3. Flight aerodynamics, stabilization and control of missiles and component performances, unguided fin, low spin and high spin stabilization.
4. Disposition missile design, Cases of missiles loading forces and moments, strain and stresses of missiles design
5. Missile Propulsion system integration and optimization and thrust vector control.

practical teaching

1. Payload design preliminary solution
2. Missiles projectiles preliminary design guided and unguided
3. Concept of missile tactical mission, preliminary design of requirements and performances
4. Seminar case study of missile or rocket preliminary design for new missile of chosen mission, presentation of solution.
5. Critical technology in project designs a consulting for solutions optimization.
Conditions for attend
Welcome, presence or distance contact,
Project design obligation

prerequisite

learning resources

1. M. Milinovic: Basics of missiles and launchers design (serb), University of Belgrade Faculty of ME 2002., textbook
2. M. Milinovic - Basics of missiles launchers design (eng.), University of Belgrade Faculty of ME 2000., layhandout
3. M. Milinovic, M. Holclajtner - Basics of missiles design (serb), University of Belgrade Faculty of ME 2004., layhandout

number of hours

total number of hours: 45

active teaching (theoretical)

lectures: 18

active teaching (practical)

auditory exercises: 6
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 12
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 1
check and assessment of projects: 3
colloquium, with assessment: 0
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 25
project design: 35
final exam: 30
requirements to take the exam (number of points): 35

references

O.Vucurovic , The basic of rocket design . Univers. of Belgrade , FME,Monograph, 2003.
O.Vucurovic The basic of launchers design ,Univers. of Belgrade , FME,Monograph, 2006.
Eugene L. Fleeman, Tactical Missile Design, 2001 AIAA, USA

Missile Guidance and Control

ID: MSc-0690
teaching professor: Мицковић М. Дејан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 2
final exam: written
parent department: weapon systems

goals

Acquiring knowledge about projectile guidance and control and its application in the areas of research and development, design, manufacturing, marketing, operational use and analysis of modern guided missiles. Mastering the methodology of calculation of dynamic characteristics of guided missiles (maneuverability, controlability, stability, eigen-frequencies, etc..) and synthesis of autopilot and guidance law for a method of "three-point" and proportional navigation.

learning outcomes

Student obtains general knowledge in the areas of analysis and synthesis of guided missile systems, which enables participation and communication in the working teams involved in the development of guided missiles. Using modern software tools developed in MATLAB and Simulink, students are qualified for the calculation of trajectories of guided missiles, the calculation of aerodynamic transfer functions and synthesis of autopilot and guidance system of a missile. Student possess basic knowledge of verification and assessment of quality of guided missiles.

theoretical teaching

1. Introduction to the Theory of missile guidance and control (considered the basic principles of guidance and control systems)
2. General requirements and methods of designing an autopilot (block is dedicated to improving the dynamic properties of missiles with autopilot)
3. Theoretical basis of proportional navigation (examines the proportional navigation as one of the fundamental laws of guidance)
4. Theoretical basis of method of guidance the "three-point" "(method of guidance the" three-point" is the second fundamental law of guidance that has found application in a large number of rockets)

practical teaching

1. Practical implementation of guided missiles (Different design solutions of guided missiles are analyzed in order to evaluate the role of guidance and control subsystem. Application of MATLAB and Simulink in the design)
2. Design of the autopilot of pitch and roll
3. Guided missiles simulation (Using Simulink program students are trained in the selection of parameters PN),
4. Missile guidance system synthesis method, "three-point" (differential expansion parameters are determined by the frequency method and numerical simulation)
5. Project of homing system of a missile (Work includes calculation of the aerodynamic transfer functions and synthesis of autopilot and guidance systems)

prerequisite

Passed exams (preferred): Flight Dynamics of Projectiles, Aerodynamics of Projectiles, Fundamentals of Automatic Control

learning resources

2. Cuk, D.: Lectures from Missile Guidance and Control, Faculty of Mechanical Engineering, Belgrade, 2002. (in Serbian)

number of hours

total number of hours: 30

active teaching (theoretical)

lectures: 8

active teaching (practical)

auditory exercises: 10
laboratory exercises: 0
calculation tasks: 3
seminar works: 0
project design: 3
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 2
colloquium, with assessment: 2
test, with assessment: 0
final exam: 2

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 25
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 20
final exam: 50
requirements to take the exam (number of points): 25

references

P. Garnel: Guided Weapon Control System, Pergamon Press, New York, 1980.
Danilo Ćuk: Design of Beam-Riding Laser Guidance System, MTI, 1998.
Danilo Ćuk: Theory of Homing Systems, Proportional Navigation, MTI, 1998.

Missile Guidance and Control

ID: MSc-0100
teaching professor: Благојевић Ђ. Ђорђе
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 2
final exam: written
parent department: weapon systems

goals

Acquiring knowledge about guidance and control and application in the areas of research and development, construction, manufacturing, marketing, operational use and analysis of modern guided missiles. Mastering the methodology of calculation of dynamic characteristics of guided missiles (agility, maneuverability, stability, eigen frequencies, etc..) and synthesis of autopilot and guidance law for a method of "three-point and proportional navigation.

learning outcomes

Student obtains general knowledge in the areas of analysis and synthesis of guided missile systems, which enables participation and communication in the working teams involved in the development of guided missiles. Using modern software tools developed in MATLAB and Simulink, are qualified for the calculation of trajectories of guided missiles, the calculation of aerodynamic transfer functions and synthesis of autopilot and guidance system missile. Possess basic knowledge of verification and assessment of quality of guided missiles.

theoretical teaching

AT-1 Introduction to the Theory of missile guidance and control (considered the basic principles of guidance and control systems),
AT-2 General requirements and methods of designing an autopilot (block is dedicated to improving the dynamic properties of missiles with autopilot),
AT-3 Theoretical basis of proportional navigation (examine the proportional navigation (PN) as one of the fundamental laws of guidance)
AT-4 Theoretical basis of method of guidance "the three-point"(method of guidance "the three-point" is the second fundamental law of guidance that has found application in a large number of rockets)

practical teaching

PA-1 Practical implementation of guided missiles (analyzed different construction solutions guided missiles in order to evaluate the role of guidance and control subsystem. Application of MATLAB and Simulink in the design),
PA-2 Design of the autopilot pitch and roll,
PA-3 Guided missiles Simulation (Using Simulink program students are trained in the selection of parameters PN),
PA-4 missile guidance system synthesis method, " three-point "(differential expansion parameters are determined by the frequency method and numerical simulation)
PS-1 System Project of guided missile (Seminar work includes calculation of the aerodynamic transfer functions and synthesis of autopilot and guidance systems).

prerequisite

Preferred conditions: Passed exams from missile flight dynamics, aerodynamics of missiles and automatic control

learning resources

Dr. Danlo Cuk: Lectures on subjects Missile Guidance and Control, Faculty of Mechanical Engineering , Belgrade, 2002. (handouts)

number of hours

total number of hours: 30

active teaching (theoretical)

lectures: 12

active teaching (practical)

auditory exercises: 6
laboratory exercises: 0
calculation tasks: 0
seminar works: 3
project design: 0
consultations: 3
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 1
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 25
laboratory exercises: 0
calculation tasks: 0
seminar works: 20
project design: 0
final exam: 50
requirements to take the exam (number of points): 25

references

Missile Propulsion

ID: MSc-0689
teaching professor: Елек М. Предраг
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 4
final exam: written
parent department: weapon systems

goals

Introducing students to the fundamentals of determination of rocket engines performance parameters. Introducing students to the design of rocket engines with liquid and solid propellants, as well as special units of liquid rocket engines. Fundamentals of thrust vector control of rocket motors. Introduction to methods of rocket engines testing.

learning outcomes

Student is capable for work on calculation and design of rocket engine with solid and liquid propellants. Student is also qualified for experimental work in the field of rocket engine testing.

theoretical teaching

1. Performance parameters of solid propellants rocket motors (Fundamentals of combustion of solid rocket propellants; pressure equation in the solid rocket motor, pressure stability, thrust of rocket engine)
2. Performance parameters of liquid propellants rocket engines (Fundamentals of combustion of liquid propellants; characteristic length and time of residence; ignition, injectors)
3. Heat transfer in rocket engines (Fundamentals of heat transfer in rocket engines, thermal protection, cooling of liquid propellants rocket engines)
4. Design of rocket engine with solid propellants (Fundamentals of design of solid propellants rocket motors, thrust vector control, nozzle design, chamber design; design of propellant charge)
5. Design of rocket engines with liquid propellants (Fundamentals of design of liquid propellants rocket engines; chamber design; turbo-pump power systems; tank pressurization systems; thrust vector control systems)
6. Testing of rocket engines (Research, development and verification tests)

practical teaching

1. Performance parameters of solid propellants rocket motors (Examples of calculations; introduction to the software package BALIST)
2. Performance parameters of liquid propellants rocket engines (Examples of calculations; introduction to the software package COMBUS)
3. Heat transfer in rocket motors (Calculation of thermal protection of rocket motor with solid propellants; Calculation of chamber cooling in the case of liquid propellants rocket engine)
4. Design of rocket engines with solid propellants (Examples of design calculations)
5. Design of rocket engines with liquid propellants (Examples of the calculation of subsystems)

prerequisite

Passed exams (preferred): Fundamentals of projectile propulsion, Thermodynamics B

learning resources

1. Elek, P.: Missile propulsion - lectures, Faculty of Mechanical Engineering, Belgrade, 2012. (in Serbian)
2. Blagojevic, Dj.: BALIST - Program for calculation of performance parameters of solid propellant rocket motors, Belgrade, 1998.

number of hours

total number of hours: 45

active teaching (theoretical)

lectures: 18

active teaching (practical)

auditory exercises: 9
laboratory exercises: 3
calculation tasks: 3
seminar works: 3
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 3
check and assessment of projects: 0
colloquium, with assessment: 3
test, with assessment: 0
final exam: 3

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 30
laboratory exercises: 0
calculation tasks: 0
seminar works: 30
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

Jaukovic, Dj.: Fundamentals of rocket engineering; Part I: Rocket propulsion, Military Academy, 1972. (in Serbian)
Jojic, B., Blagojevic, Dj., Pantovic, A., Milosavljevic, V.: Hanbook for sounding rockets design, Part II: Propulsion group, SAROJ, Belgrade, 1978. (in Serbian)
Sutton, G.P., Biblarz, O.: Rocket propulsion elements, 7 ed, John Wiley and Sons, 2001.
Hill, P., Peterson, C.: Mechanics and Thermodunamics of Propulsion, Pearson, 2010.

Optical devices and optoelectronics

ID: MSc-0123
teaching professor: Мицковић М. Дејан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 2
final exam: oral
parent department: weapon systems

goals

The aim of this course is to enable students, future mechanical engineers - designers of military systems, the acquisition of knowledge necessary to the cooperation with the designers of complex optical and optoelectronic systems. After completion of lectures and exercises, students should be able to set and calculate basic optical systems.

learning outcomes

The subject allows students, future mechanical engineers - designers of military systems to:
- Set up basic optical systems (lenses, working systems, oculars, Kepler and Galileo's scheme of telescope system);
- Calculate an optical system using sophisticated codes for optical system design.

theoretical teaching

Basic assumptions and definitions used in optics.
Ideal and paraxyal optics as the basic approximations used in the design of optical systems.
1. Theory of aberrations and the theory that defines the deviation of real established character from an ideal character.
2. Rating the quality of image formed by optical systems.
3. Losses of light energy during propagation through the optical system.
4. Basic parameters and laws in optoelectronics. Principles of the laser. Main components that make up the laser system. Laser rangefinder.

practical teaching

1. Description of the major optical components that make up the conventional optical systems.
2. Calculation of ideal and paraxyal rays propagation through the optical system.
3. Calculation of real rays propagation through the optical system.
4. Design of a telescopic system (Kepler and Galileo's telescope system scheme).
5. Working principle of the picture amplifier.
6. Working principle of optical radiation detectors. Explained in detail the working principle of CCD detectors.
7. Working principle of the laser and review of basic components that make up the laser system. Explained in detail the laser rangefinder.
8. Working principle of thermal imaging and review of the basic components of different types of thermal imaging units.

prerequisite

There are no special conditions for attending the subject.

learning resources

1. Vasiljević D.: Optical Devices and Optoelectronics, Facultz of Mechanical Engineering,

Belgrade, 2005
2. Software package OSLO – Optical Surface Layout and Optimization LT ver. 5.4
OSLO Optics Reference Manual, CCO

number of hours

total number of hours: 30

active teaching (theoretical)

lectures: 12

active teaching (practical)

auditory exercises: 6
laboratory exercises: 0
calculation tasks: 0
seminar works: 6
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 1
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 20
laboratory exercises: 0
calculation tasks: 0
seminar works: 30
project design: 0
final exam: 40
requirements to take the exam (number of points): 30

references

Physics of Explosive Processes

ID: MSc-0271
teaching professor: Јарамаз С. Слободан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 6
final exam: written
parent department: weapon systems

goals

The goal of course is that students learn the basic principles of combustion of materials and physics of explosion which are of importance for the realization of a function of weapon systems. Students should learn the contents of the process of explosion and burning of gunpowder and rocket propulsion materials as integrated chemical-technological systems.

learning outcomes

Mastering calculations of physics of explosion processes that influence on warhead mechanisms and target efficiency. Student understand influencing parameters on the energy release by combustion processes and form a scientific and experimental base for the development and creation of new knowledge in the field of energetic materials and energy release processes in defense technologies and products.

theoretical teaching

1. Fundamentals of thermochemistry and thermodynamics of the explosive processes
2. Explosives sensitivity to external influences
3. Fundamentals of the hydrodynamic theory of detonation
4. The effect of explosions on the surrounding environment
5. Contact detonations. Active part of the explosive charge
6. Explosive propulsion. The formation of plane detonation wave
7. General assumptions and laws of ignition of fuel-oxidizer systems and exothermic reaction
8. Combustion of solid rocket propellants, powders and pyrotechnic mixtures (kinetics and thermochemistry)
9. Combustion products and energy characteristics of the various types of fuel mixtures and methods of measuring the burning rate

practical teaching

1. Calculation of thermochemistry and thermodynamics of the explosive processes
2. Explosives sensitivity to external influences. Applications
3. Fundamentals of the hydrodynamic theory of detonation. Selected examples
4. The effect of explosions on the surrounding environment. Selected examples
5. Contact detonations. Active part of the explosive charge
6. Explosive propulsion. The formation of plane detonation wave. Examples
7. Ignition and combustion of gas and liquid reactants and boundary conditions
8. Kinetic properties of powder and rocket propellants and models of decomposition of solid fuels
9. External influences and methods of measuring kinetic and energy parameters in different environmental conditions

prerequisite

There are no obligatory prerequisites. Passed exam preferred: Fundamental of projectile propulsion

learning resources

1. Jaramaz, S.: Physics of Explosion, Faculty of mechanical Engineering, Belgrade, 1997.
2. Maksimovic, P.V.: Technology of explosive materials, Military Publishig Company, Belgrade, 1972 (in Serbian)
3. Adzic, M.: Fundamentals of combustion, Faculty of Mechanical Engineering, Belgrade, 2007 (in Serbian)
4. Milinovic, M.: Principles of combustion of solid propellants, Принципи сагоревања чврстих погонских материја, Faculty of Mechanical Engineering, Belgrade, 2007 (in Serbian)

number of hours

total number of hours: 75

active teaching (theoretical)

lectures: 30

active teaching (practical)

auditory exercises: 6
laboratory exercises: 8
calculation tasks: 16
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 10
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 60
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

Professional Practice M - SIN

ID: MSc-0692
teaching professor: Елек М. Предраг
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 1
final exam: seminar works
parent department: weapon systems

goals

Practical experience and student's stay in the environment in which he will realize his professional career. Identifying the basic functions of the business system in the field of design, development and production, as well as the roles and tasks of mechanical engineer in such a business system.

learning outcomes

Students get practical experience on the organization and functioning of the environment in which they will apply their knowledge in their future professional career. Student identifies models of communication with colleagues and business information flows. The student recognizes the basic processes in the design, manufacture, maintenance, in the context of his future professional competence. Personal contacts and acquaintances are established that student will be able to use during study or entering into future employment.

theoretical teaching

practical teaching

Practical work involves working in organizations that perform various activities in connection with mechanical engineering. Selection of thematic areas and commercial or research organizations is carried out in consultation with the concerned professor. Generally a student can perform the practice in manufacturing organizations, project and consulting organizations, organizations engaged in mechanical equipment maintenance, public utility companies and some of the laboratories at Faculty of Mechanical Engineering. The practice may also be made abroad. During practice, students must keep a diary in which he will enter a description of the tasks performed, the conclusions and observations. Following the practice they must make a report to defend of the subject professor. The report is submitted in the form of the paper.

prerequisite

learning resources

number of hours

total number of hours: 46

active teaching (theoretical)

lectures: 0

active teaching (practical)

auditory exercises: 0
laboratory exercises: 0
calculation tasks: 0

seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 0
test, with assessment: 0
final exam: 46

assessment of knowledge (maximum number of points - 100)

feedback during course study: 70
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 0

references

Projectile Design

ID: MSc-0196
teaching professor: Јарамаз С. Слободан
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 4
final exam: written
parent department: weapon systems

goals

The main objective of the course is that students understand the importance, the basic concepts and methods of projectile design as an integral part of the science of weapons systems. Students should understand the key ideas about the types and purpose of projectiles, safety in the use and mechanisms of action.

learning outcomes

Student gets contemporary knowledge about the main types of projectiles (high-explosive, armor-piercing, special) and the basics of their design. Student could use methods of calculation of different types of projectiles.

theoretical teaching

1. Introduction to the projectile design. Basics of projectile safety during the movement in the gun barrel. Stress of projectile elements in the gun barrel.
2. High-explosive projectiles. Fragmentation warhead. Number, individual mass and shape of fragments. Configuration and direction of the fragments beam. Fragments ' ballistics. Efficiency and specific efficiency of fragmentation warhead. Blast effect.
3. Shaped charge projectiles. Theoretical basis for a shaped charge effect. Hydrodynamic theory. Misznay-Shardin's effect.
4. Armor-piercing projectiles. The influence of the mechanical characteristics of the projectile and armor on the penetration process.
5. Special purpose projectiles. Design characteristics of special-purpose projectiles. Smoke projectiles. Illuminating projectiles. Incendiary projectiles. Aerosol projectiles.

practical teaching

1. Introduction to projectile design
Projectile safety during movement in the gun barrel. Stress of projectile elements in the gun barrel. Selected problems.
2. High-explosive projectles
Fragmentation warhead. Number, individual mass and shape of fragments. Configuration and direction of the fragments beam. Fragments ' ballistics. Efficiency and specific efficiency of fragmentation warhead. Examples
3.High-explosive projectиles
Measures to increase the fragmentation effect of the projectile. Blast effect. Examples.
4. Shaped charge projectiles. Examples.
5. Term paper - Preparation of seminar work with the subject determined by arrangement with the student.
6. Armor-piercing projectiles
The influence of the mechanical characteristics of the projectile and armor on penetration process. Examples.
7. Armor-piercing projectiles
Depth of penetration. Analysis of selected examples.

prerequisite

Passed exam (preferred): Physics of explosive processes

learning resources

1. Jaramaz, S.: Warheads Design and Terminal Ballistics, Faculty of Mechanical Engineering, Belgrade, 2000
2. Stamatovic, A.: Projectile design, Ivexy, Belgrade, 1995
3. Jaramaz, S.: Manuscript for lessons

number of hours

total number of hours: 45

active teaching (theoretical)

lectures: 18

active teaching (practical)

auditory exercises: 4
laboratory exercises: 0
calculation tasks: 10
seminar works: 2
project design: 0
consultations: 2
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 2
check and assessment of projects: 0
colloquium, with assessment: 2
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 30
laboratory exercises: 0
calculation tasks: 0
seminar works: 30
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

Rocket Propulsion

ID: MSc-0168
teaching professor: Благојевић Ђ. Ђорђе
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 4
final exam: written
parent department: weapon systems

goals

Introduce students to the basics of the rocket engines performance calculation. Introduce students to design of rocket motors with liquid and solid fuel, and special units of liquid rocket engines. Basics of thrust vector control. Introduction to methods of rocket engines testing.

learning outcomes

The student is able to work independently on a calculation and design of rocket engines with solid and liquid propellants. Student is also qualified for the experimental work in testing rocket engines.

theoretical teaching

Performances of rocket engine with solid propellants (Basics of combustion of solid propellants; equations of pressure; the stability of pressure; thrust of rocket engine; introduction to the software package BALIST)
Performances of rocket engines with liquid propellants (Basics of combustion of liquid propellants; characteristic length and residence time; ignition, injectors, introduction to the software package COMBUS)
Heat transfer in rocket engines (Fundamentals of heat transfer in rocket engines; thermal protection and cooling of rocket engines; introduction to software packages CCOOL and RCOOL)
Design of rocket engines with solid propellants (Basic design of solid rocket motors; thrust vector control; design of nozzle and chamber, propellant grain design, TVC systems)
Design of rocket engines with liquid propellants (Basic design of liquid rocket engines; chamber design; turbopump feeding systems, tank pressurisation systems, tanks)
Testing of rocket engines (Research, development and verification tests)

practical teaching

Performances of rocket engine with solid propellants; the pressure equation in the solid rocket motor; practical work with the software package BALIST
Performances of rocket engines with liquid propellants; characteristic length and residence time; calculation of injectors; practical work with the software package COMBUS
Heat transfer in rocket engines; thermal protection and cooling of liquid rocket engines; practical work with software packages CCOOL and RCOOL
Design of rocket engines with solid propellants, propellant grain design; TVC systems
Design of rocket engines with liquid propellants, design of chamber; turbopump feeding systems, tank pressurisation systems, tanks)
Testing of rocket engines

prerequisite

None

learning resources

1. Elek, P.: Rocket propulsion - manuscript for lectures, Belgrade, 2010. (in Serbian)
2. Blagojevic, Dj.: BALIST - Software for determination of solid rocket motor performances, Belgrade, 1998.

number of hours

total number of hours: 45

active teaching (theoretical)

lectures: 18

active teaching (practical)

auditory exercises: 10
laboratory exercises: 0
calculation tasks: 5
seminar works: 0
project design: 0
consultations: 3
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 2
check and assessment of lab reports: 0
check and assessment of seminar works: 0
check and assessment of projects: 0
colloquium, with assessment: 2
test, with assessment: 0
final exam: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 30
laboratory exercises: 0
calculation tasks: 30
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

Sutton, G.P., Biblarz, O,.:Rocket propulsion elements, Wiley Interscience, 2000.

Terminal Ballistics

ID: MSc-0691
teaching professor: Елек М. Предраг
level of studies: M.Sc. (graduate) academic studies
ECTS credits: 4
final exam: written
parent department: weapon systems

goals

The main goal of the subject is that students understand the importance, the basic concepts and methods of terminal ballistics, as an integral part of the science of weapons systems. Students should understand the key ideas about the projectile/target interaction and their use in projectile design as well as ballistic protection.

learning outcomes

Student gets contemporary knowledge about the main types of projectile effects (penetration, fragmentation and blast) and the fuzes as an important functional part of the projectile in terms of terminal ballistics. Student masters calculation methods of all types of projectile effects and their use.

theoretical teaching

1. Scope of terminal ballistics
The effect of projectile on target. Types of projectiles. Types of targets. Tasks of terminal ballistics. Behavior of materials under dynamic conditions.
2. Penetration mechanics
Fundamentals of penetration mechanics. Armor piercing projectiles. Experimental determination of penetration. Long rod penetration. Shaped charge jet penetration.
3. Fragmentation
Mechanism of projectile fragmentation. Fragment velocity. Mass distribution of fragments. Experimental determination of the efficiency of fragmentation projectile.
4. Blast effect
Shock wave, pressure and impulse. Blast effect of projectiles. Underground explosion. Underwater explosion
5. Fuzes
Classification of fuzes. Functional composition of fuzes. Calculation of reliability and safety of fuzes. Testing of fuzes.

practical teaching

1. Approaches to solving problems in terminal ballistics
Examples of target kill probability. Models of material behavior under dynamic loads.
2. Penetration/Perforation
Simple penetration models penetration for thin targets. Penetration at high velocities.
3. Penetration/Perforation
Models of shape charge jet and long rod penetration.
4. Workshop - Preparation of the paper with a topic that is determined by arrangement with the student.
5. Fragmentation
Experimental evaluation of the efficiency of projectile fragmentation.
6. Blast effect
Determination of blast effect parameters.

7. Fuzes
Models of the effect of certain types of fuzes. Calculation of reliability and safety of fuzes.

prerequisite

Exams passed (preferred): Projectile design, Physics of explosive processes

learning resources

1. Jaramaz, S.: Warheads Design and Terminal Ballistics, Faculty of Mechanical Engineering, Belgrade, 2000.
2. Stamatovic, A.: Projectile design, Ivexy, Belgrade, 1995 (in Serbian)
3. Krsic, N.: Design of fuzes, VINC, Belgrade, 1986 (in Serbian)
4. Elek, P.: Manuscript for lectures, Faculty of Mechanical Engineering, Belgrade, 2010.

number of hours

total number of hours: 45

active teaching (theoretical)

lectures: 18

active teaching (practical)

auditory exercises: 5
laboratory exercises: 0
calculation tasks: 9
seminar works: 2
project design: 0
consultations: 2
discussion and workshop: 0
research: 0

knowledge checks

check and assessment of calculation tasks: 0
check and assessment of lab reports: 0
check and assessment of seminar works: 3
check and assessment of projects: 0
colloquium, with assessment: 3
test, with assessment: 0
final exam: 3

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 30
laboratory exercises: 0
calculation tasks: 0
seminar works: 30
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

Backman, M.E.: Terminal Ballistics, NWC China Lake, California, 1976.
Carleone, J.: Tactical Missile Warheads, Progress in Astronautics and Aeronautics, AIAA, Vol. 155, Washington, 1983.
Meyers, M.A.: Dynamic Behavior of Materials, Wiley-Interscience, 1994.