University of Belgrade

Faculty of Mechanical Engineering

Course catalog

Bachelor (B.Sc.) Academic Studies – Mechanical Engineering

Belgrade

2022.

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MFB

B.Sc. work

Skill Praxis B

B.Sc. work

ID: BSc-0361
responsible/holder professor: - -. -
teaching professor/s: Aleksendrić S. Dragan, Aleksendrić S. Dragan, Aleksendrić S. Dragan, Anđelić M. Nina, Anđelić M. Nina, Aranđelović D. Ivan, Babić R. Bojan, Babić R. Bojan, Bajc S. Tamara, Bakić M. Gordana, Balać M. Igor, Balać M. Igor, Banjac B. Milan, Bačkalov A. Igor, Bengin Č. Aleksandar, Bengin Č. Aleksandar, Bengin Č. Aleksandar, Bengin Č. Aleksandar, Bengin Č. Aleksandar, Bengin Č. Aleksandar, Blagojević A. Ivan, Blagojević A. Ivan, Blagojević A. Ivan, Božić O. Ivan, Bošnjak M. Srđan, Bugarić S. Uglješa, Buljak V. Vladimir, Buljak V. Vladimir, Vasić-Milovanović I. Aleksandra, Veg A. Emil, Veg A. Emil, Veg A. Emil, Veljković A. Zorica, Vencl A. Aleksandar, Vencl A. Aleksandar, Vencl A. Aleksandar, Vorotović S. Goran, Vorotović S. Goran, Vorotović S. Goran, Vorotović S. Goran, Gašić M. Vlada, Genić B. Srbislav, Genić B. Srbislav, Genić B. Srbislav, Genić B. Srbislav, Genić B. Srbislav, Gnjatović B. Nebojša, Gojak D. Milan, Gojak D. Milan, Gojak D. Milan, Grbović M. Aleksandar, Grbović M. Aleksandar, Davidović S. Nikola, Dinulović R. Mirko, Đukić Z. Miloš, Đukić Z. Miloš, Elek M. Predrag, Elek M. Predrag, Živanović T. Saša, Žunjić G. Aleksandar, Zlatanović J. Ivan, Zlatanović J. Ivan, Zrnić Đ. Nenad, Ivanov D. Toni, Ivanov D. Toni, Jakovljević B. Živana, Janković Z. Novica, Janković Z. Novica, Jevtić T. Dejan, Jevtić T. Dejan, Jevtić T. Dejan, Jeli V. Zorana, Jeli V. Zorana, Jeli V. Zorana, Jeftić D. Branislava, Jeftić D. Branislava, Jeftić D. Branislava, Jeftić D. Branislava, Jovanović V. Vladimir, Jovanović V. Vladimir, Jovanović V. Vladimir, Jovanović V. Vladimir, Jovanović V. Vladimir, Jovanović Ž. Radiša, Jovović M. Aleksandar, Jovović M. Aleksandar, Jovović M. Aleksandar, Jovović M. Aleksandar, Jovović M. Aleksandar, Karličić V. Nikola, Karličić V. Nikola, Karličić V. Nikola, Karličić V. Nikola, Karličić V. Nikola, Knežević M. Dragan, Kokotović M. Branko, Kolarević M. Nenad, Kolarević M. Nenad, Kolarević M. Nenad, Komatina S. Mirko, Komatina S. Mirko, Kostić A. Ivan, Kostić A. Ivan, Kostić P. Olivera, Lazarević P. Mihailo, Lazić V. Dragan, Lazović M. Goran, Lazović-Kapor M. Tatjana, Lazović-Kapor M. Tatjana, Lečić R. Milan, Lečić R. Milan, Lukić M. Petar, Lukić M. Petar, Lučanin J. Vojkan, Lučanin J. Vojkan, Manić G. Nebojša, Manić G. Nebojša, Manić G. Nebojša, Manić G. Nebojša, Manić G. Nebojša, Marinković B. Aleksandar, Marinković B. Aleksandar, Marković D. Miloš, Marković D. Miloš, Marković D. Dragan, Matija R. Lidija, Matija R. Lidija, Matija R. Lidija, Matija R. Lidija, Milanović D. Dragan, Milanović D. Dragan, Milivojević M. Aleksandar, Milivojević S. Sanja, Milićev S. Snežana, Milković D. Dragan, Milovančević Đ. Milorad, Milovančević Đ. Milorad, Milovančević M. Uroš, Miloš V. Marko, Milošević-Mitić O. Vesna, Milošević-Mitić O. Vesna, Miljić L. Nenad, Miljković Đ. Zoran, Miljković Đ. Zoran, Misita Ž. Mirjana, Mitić R. Saša, Mitić R. Saša, Mitić R. Saša, Mitrović B. Časlav, Mitrović B. Časlav, Mitrović B. Časlav, Mitrović B. Časlav, Mitrović B. Časlav, Mitrović B. Časlav, Mitrović B. Časlav, Mitrović B. Časlav, Mitrović B. Časlav, Mitrović M. Radivoje, Mitrović M. Radivoje, Mitrović M. Radivoje, Mitrović R. Nenad, Mitrović R. Nenad, Mitrović R. Nenad, Mitrović R. Nenad, Mitrović R. Nenad, Mišković Z. Žarko, Mišković Z. Žarko, Mladenović M. Goran, Mladenović M. Goran, Motok D. Milorad, Nedeljković S. Miloš, Obradović O. Marko, Obradović O. Marko, Obradović O. Marko, Obradović O. Marko, Obradović O. Marko, Peković M. Ognjen, Peković M. Ognjen, Petrašinović M. Danilo, Petrović B. Nebojša, Petrović V. Milan, Petrović Lj. Aleksandar, Petrović Lj. Aleksandar, Petrović Lj. Aleksandar, Petrović Lj. Aleksandar, Petrović Lj. Aleksandar, Petrović M. Milica, Petrović S. Ana, Petrović S. Ana, Pjević D. Miloš, Pjević D. Miloš, Popkonstantinović D. Branislav, Popkonstantinović D. Branislav, Popkonstantinović D. Branislav, Popkonstantinović D. Branislav, Popović D. Mihajlo, Popović D. Mihajlo, Popović D. Olivera, Popović D. Olivera, Popović J. Slobodan, Popović J. Slobodan, Popović M. Vladimir, Prokić-Cvetković M. Radica, Prokić-Cvetković M. Radica, Puzović M. Radovan, Puzović M. Radovan, Puzović M. Radovan, Radaković J. Zoran, Radić B. Dejan, Radić B. Dejan, Radić B. Dejan, Radić B. Dejan, Radić B. Dejan, Rakićević B. Branislav, Rakićević B. Branislav, Ribar N. Srđan, Rudonja R. Nedžad, Rudonja R. Nedžad, Svorcan M. Jelena, Svorcan M. Jelena, Simonović D. Vojislav, Simonović D. Vojislav, Simonović M. Aleksandar, Spasojević-Brkić K. Vesna, Stamenić S. Mirjana, Stamenić S. Mirjana, Stamenić S. Mirjana, Stamenić S. Mirjana, Stamenić S. Mirjana, Stamenić V. Zoran, Stamenić V. Zoran, Stamenić V. Zoran, Stamenić V. Zoran, Stanković M. Ivana, Stanković M. Ivana, Stanković M. Ivana, Stanković M. Ivana,

Stevanović D. Vladimir, Stevanović D. Nevena, Stojadinović M. Slavenko, Stojiljković D. Dragoslava, Stojiljković D. Dragoslava, Stojiljković D. Dragoslava, Stojiljković D. Dragoslava, Stojiljković D. Dragoslava, Stojić M. Tomislav, Stojić M. Tomislav, Stojićević D. Miša, Stojićević D. Miša, Stojićević D. Miša, Stojićević D. Miša, Tanasković D. Jovan, Tanasković D. Jovan, Todić N. Ivana, Todić N. Ivana, Todorović I. Ružica, Todorović M. Dušan, Todorović M. Dušan, Todorović M. Dušan, Todorović M. Dušan, Todorović M. Dušan, Todorović N. Maja, Tucaković R. Dragan, Ćoćić S. Aleksandar, Ćoćić S. Aleksandar, Čantrak S. Đorđe, Čantrak S. Đorđe, Šiniković B. Goran, Šiniković B. Goran
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: written+oral
parent department: MFB

goals
Applying the acquired knowledge and methods in order to solve the given tasks within the chosen field. The task refers to studying the problem, its structure and complexity, and coming up with adequate solutions. The student acquires knowledge on the manner, structure and form of writing a project-report which refers to the activities undertaken within the given topic of the Final course. The student acquires the adequate level of knowledge, skills and competences referring to the problem field, implemented methods and obtained results. The student also acquires the ability to publicly present the results of independent work, organised in an appropriate form.

learning outcomes
Upon the successful completion of this course, students should be able to:

- apply the previously acquired knowledge in the studied fields,
- recognise the structure of the given problem, suggest system analysis and define the directions for its solving,
- expand the knowledge in the field of the selected topic based on their own use of literature,
- briefly describe the solution of the given task and present it on their own,
- communicate efficiently with the engineering community and the society as a whole.

theoretical teaching
It is developed individually in accordance with the related field of the topic of the Final course. Upon agreement with the course teacher, the student defines the task, which points towards the necessary theoretical knowledge that has been acquired and possibly new knowledge that has yet to be acquired for the given task to be solved.

practical teaching
Practical teaching contents refer to the implementation of the acquired knowledge through laboratory exercises, Skill Praxis B and professional visits to companies and factories, related to the field of the topic of the Final course.

prerequisite
The student must have passed the exam of the course the course report belongs to.

learning resources
Existing laboratory equipment, textbooks and library references.

number of hours: 75

active teaching (theoretical): 30
lectures: 10
elaboration and examples (revision): 20

active teaching (practical): 30
auditory exercises: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 15
consultations: 15
discussion and workshop: 0
research: 0

knowledge checks: 15
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): 40

references
Current textbooks and magazines related to the field of the topic of the Final course.

Skill Praxis B

ID: BSc-1393
responsible/holder professor: Miloš V. Marko
teaching professor/s: Bojović A. Božica, Zrnić Đ. Nenad, Ilić B. Dejan, Jeli V. Zorana, Jovović M. Aleksandar, Kalajdžić D. Milan, Lazić V. Dragan, Marković D. Miloš, Milić B. Srđan, Milković D. Dragan, Miloš V. Marko, Miljić L. Nenad, Misita Ž. Mirjana, Mitrović B. Časlav, Petrović B. Nebojša, Popović D. Olivera, Rakićević B. Branislav, Simonović D. Vojislav, Sretenović Dobrić A. Aleksandra, Stanković M. Ivana
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 1
final exam: seminar works
parent department: MFB

goals
Practical experience in ambient similar to the ambient where the graduated student - mechanical engineer will realize his own professional carrier as an engineer.

Recognizing the basic functioning of the business systems especially in domain of development, design and manufacturing of the mechanical systems.

learning outcomes
Students can reach practical experiences about the organization and functioning the business systems that deal in mechanical engineering.

Student may be introduced in business communication, design processes, development processes and manufacturing

theoretical teaching
Introduction, aim, content and program of work.

practical teaching
The skill praxis is organized in a way which is the most appropriate for the student.

Practical work must be realized in the company where the mechanical engineering is the primary occupation. What the student will work, see or follow must be defined in coordination with the professor. Generally, student can realize practical work in: manufacturing companies design companies, companies which work maintenance in mechanics or in laboratories that belong to the Mechanical faculty.

After finishing the practical work, the student must prepare the Report and this Report needs to be defended in front of professor.

prerequisite
-

learning resources
Initial resources are laboratories that belong to the Mechanical faculty.

number of hours: 90

active teaching (theoretical): 2
lectures: 2
elaboration and examples (revision): 0

active teaching (practical): 78
auditory exercises: 0
laboratory exercises: 0

calculation tasks: 0
seminar works: 30
project design: 0
consultations: 0
discussion and workshop: 0
research: 48

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

references

AEROSPACE ENGINEERING

- Aerodynamic Constructions
- Aerodynamics
- Aircraft propulsion and systems
- Computational methods in aeronautics
- Design and Technology of Airplane Manufacture
- FEM Analysis
- Fundamentals of aerotechnics
- Introduction to engineering simulations
- Light and Composite Structures
- Mechanics of Flight
- Structural Analysis of Flying Vehicles
- Theory of Elasticity
- Windturbines

Aerodynamic Constructions

ID: BSc-0942
responsible/holder professor: Kostić A. Ivan
teaching professor/s: Kostić A. Ivan, Kostić P. Olivera, Mitrović B. Časlav
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: written
parent department: aerospace engineering

goals
The aim of this course is to introduce students to basic concepts of applied aerodynamics in the domain of subsonic and lower transonic speeds. The emphasis is on the aerodynamics of aircraft, where the aerodynamic characteristics of airfoils, lifting surfaces, and of complete airplane configurations are analyzed. Students will also be introduced to the fundamentals of propeller aerodynamics, as well as of the aircraft lifting surface controls.

learning outcomes
After passing the course, the student is expected to understand the fundamental laws of aerodynamics and to possess the knowledge of how to apply them for the solution of practical problems. It is expected that the student will be able to perform basic aerodynamic analyses of airfoils and lifting surfaces, as well as to determine the polar curve for the entire airplane in cruising configuration, at subsonic and lower transonic speeds.

theoretical teaching
The course consists of theoretical and practical part. Theoretical part covers the following topics: - introduction: the role and the case study of aerodynamics, aerodynamics in aeronautical and non-aeronautical applications, aerodynamic force and aerodynamic moment, international standard atmosphere; - airfoils (basic geometric characteristics, notation and families, as well as the parameters which define their aerodynamic characteristics); - lifting surfaces of finite aspect ratio (geometric and aerodynamic characteristics); - compressibility effects and their influence at higher subsonic and transonic speeds; - determination of polar curves for the complete aircraft in cruising configuration at subsonic and lower transonic speeds; - design features and aerodynamic characteristics of propellers; - control surfaces (ailerons, flaps, slots, air brakes); - aircraft aerodynamic design schemes.

practical teaching
Practical part of the course demonstrates numerical examples in the areas covered by lectures. Practical work of students is accomplished through a virtual classroom available 24 hours (internet - software MOODLE). In the workshop students have access to the professor's lectures in form of handouts, assignments and tests for practice. Practical training includes two homeworks (one individual and one collective, within the groups to which students are divided). In the first homework student performs calculations of the aerodynamic characteristics of the airplane (polar curve for cruising flight configuration), and the second is the seminar work which is publically presented. Practical training also includes the excursion - visit to the Aviation Museum - Surčin.

prerequisite
None.

learning resources
The Course includes a virtual classroom, accessible by Internet. The MOODLE software is used. Students are enrolled electronically into the classroom and have access to the professor’s handouts, quizzes and additional materials advised by the professor.

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
auditory exercises: 10
laboratory exercises: 0
calculation tasks: 5
seminar works: 0
project design: 5
consultations: 5
discussion and workshop: 5
research: 0

knowledge checks: 15
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: 2
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: 20
project design: 20
final exam: 30
requirements to take the exam (number of points): 25

references

I. Kostić: Aerodynamic constructions, Handouts, University of Belgrade, Faculty of Mechanical Engineering, Belgrade 2014.

Aerodynamics

ID: BSc-0943
responsible/holder professor: Bengin Č. Aleksandar
teaching professor/s: Bengin Č. Aleksandar, Kostić A. Ivan, Kostić P. Olivera, Mitrović B. Časlav
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 2
final exam: written
parent department: aerospace engineering

goals
The aim of the course is that students become familiar with the basic laws of aerodynamics and its application in solving practical problems. Particularly with the specific features in the compressible flow. Students will learn the basic aerodynamic aircraft configurations for different speeds, as well as the basics of aerodynamics of the vehicle. In the course students obtain basic knowledge in the field of experimental aerodynamics and its application in aerodynamic testing of the aeronautical and non-aeronautical objects.

learning outcomes
Mastering the course, the student acquires knowledge in the field of aerodynamics, with emphasis on the domain of compressible flow, as well as an understanding of the basic aerodynamic configurations of aircraft and aerodynamics of the road vehicle. He also mastered the basics of experimental aerodynamics and its application not only in the aeronautic, but also in other branches of engineering.

theoretical teaching
Lesson 1: Modeling of the flow field

Lesson 2: Compressible flow and waves in compressible flow

Lesson 3: Aerodynamic configurations of the aircrafts and road vehicles

Lesson 4: Subsonic, transonic and supersonic wind tunnels

Lesson 5: Methods of the measurement in wind tunnel tests

practical teaching
In the practical part of teaching it is demonstrated the application of the theoretical law, by solving and analysis of selected numerical examples. The practical work of students is realized by compulsory exercises and by a virtual workshop available 24 hours (MOODLE). In the virtual workshop for students are available professor's lecture notes, assignments for practice and tests for knowledge check. The practical part of the course includes consultations for homework, students work collectively within the small groups (up to five students per group).

prerequisite
Without prerequisites, but it is recommended to pass the exam of the course Aerodynamic constructions previously.

learning resources
Lectures in electronic form, internet resources.

number of hours: 30

active teaching (theoretical): 12
lectures: 8
elaboration and examples (revision): 4

active teaching (practical): 12
auditory exercises: 5

laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 5
discussion and workshop: 2
research: 0

knowledge checks: 6
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: 5

assessment of knowledge (maximum number of points - 100)

feedback during course study: 18
test/colloquium: 32
laboratory exercises: 0
calculation tasks: 0
seminar works: 20
project design: 0
final exam: 30
requirements to take the exam (number of points): 21

references

Aircraft propulsion and systems

ID: BSc-1076
responsible/holder professor: Petrović B. Nebojša
teaching professor/s: Davidović S. Nikola, Ivanov D. Toni, Peković M. Ognjen, Petrović B. Nebojša
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: oral
parent department: aerospace engineering

goals
The task of the course is to introduce students with aircraft equipment and power systems, particularly with their functions, structures and basic principles. The course should give students a global view of all of the aircraft and power systems as well as their interconnection and integrity.

learning outcomes
Through the course students gain the ability to understand the various types of existing aircraft and power systems solutions. They gain knowledge about the different types of aircraft and power system structures. This gained knowledge should allow students who choose other fields of aerospace engineering to better understand the problems involved with aircraft and power systems and should present a good base for students who choose to specialize further in this area.

theoretical teaching
Aircraft hydraulic systems, aircraft fuel systems, aircraft pneumatic systems, aircraft environmental systems, aircraft anti-icing systems, aircraft electrical systems, aircraft cabin systems, avionics, aircraft control systems, aircraft safety systems, aircraft automatic control systems, systems design and development, helicopter systems, power systems structures and their integrity, advanced systems, powerplant fuel system, powerplant hydraulic system, elements and methods for powerplant operation measurements.

practical teaching
Practical teaching is related to presentation of sample problems, analysis and discussion with students in the fields previously treated theoretically. Aircraft hydraulic systems, aircraft fuel systems, aircraft pneumatic systems, aircraft environmental systems, avionics, aircraft control systems, aircraft safety systems, aircraft automatic control systems, systems design and development, helicopter systems, power systems structures and their integrity, advanced systems, powerplant fuel system, powerplant hydraulic system, elements and methods for powerplant operation measurements.

prerequisite
Declared by the curriculum of study program / module.

learning resources
Oprema i sistemi letelica - Sistemi automatskog upravljanja leta, Janković J. (in Serbian)

Written handouts from the lectures.

Written handouts from auditory exercises.

Internet.

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
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: 15
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

Computational methods in aeronautics

ID: BSc-1074
responsible/holder professor: Peković M. Ognjen
teaching professor/s: Peković M. Ognjen, Svorcan M. Jelena, Simonović M. Aleksandar
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 4
final exam: oral
parent department: aerospace engineering

goals
Introducing students to the basics of computer applications in simulations and computations of aeronautical problems. Students are first introduced to theoretical foundations of computational methods and later through computer implementation on model problems from different areas of aeronautical engineering (aerodynamics, flight mechanics, aircraft structures...) gain working knowledge. The subject is organized so that several typical (model) problems are completely solved step-by-step from start to finish.

learning outcomes
By mastering the curriculum a student gains specific skills:

- thorough knowledge and understanding of numerical methods

- ability to use and apply basic numerical methods for solving ODE, finite difference and finite elements methods

- correlation between fundamentals in mathematics, programming, mechanics, fluid mechanics and construction analysis

theoretical teaching
• Determination of geometrical characteristics of sections

• Parameters of compressible flow - Fundamental equations for one-dimensional compressible flow

• Calculation of the flow around a cone (example of solving a problem modeled by ODE)

• Simulation of plane take-off (also example of solving a problem modeled by ODE, application of interpolation methods to aerodynamic characteristics of aircrafts)

• FEM calculation of lattice structures (example of solving sparse systems of equations with many unknowns)

practical teaching
• Determination of geometrical characteristics of sections - using a program for calculating the geometrical characteristics of sections

• Parameters of compressible flow - an interactive program for parameters of compressible flow

• Calculation of the flow around a cone (example of solving a problem modeled by ODE) - computational problem solving, obtained results and analysis

• Simulation of plane take-off (also example of solving a problem modeled by ODE, application of interpolation methods to aerodynamic characteristics of aircrafts) - a program for calculating take-off distance and velocity

• FEM calculation of lattice structures (example of solving sparse systems of equations with many unknowns) - a program for calculating stresses of two-dimensional lattices

prerequisite
There are no necessary conditions for attending the subject.

learning resources
1. Petrovic Z, Stupar S, CFD one, Faculty of Mechanical Engineering, 1992, KPN
2. Additional materials (lecture hand-writings, problem settings, task solving guidelines), DVL
3. 452, Computer laboratory SimLab, IKT/CAH

number of hours: 45

active teaching (theoretical): 15
lectures: 10
elaboration and examples (revision): 5

active teaching (practical): 20
auditory exercises: 8
laboratory exercises: 0
calculation tasks: 6
seminar works: 6
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks: 10
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: 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): 60

references
Petrovic Z, Stupar S, CFD one, Faculty of Mechanical Engineering, 1992, KPN
Cvetković, A., Radojević, S., Matlab 1, Mašinski fakultet, Beograd 2012.

Design and Technology of Airplane Manufacture

ID: BSc-1129
responsible/holder professor: Grbović M. Aleksandar
teaching professor/s: Grbović M. Aleksandar, Svorcan M. Jelena
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: written
parent department: aerospace engineering

goals
To introduce students to the process of airplane components modeling and help them to understand and apply technologies necessary for the manufacturing of these components. Students are taught skills that connect typical aircraft loads with typical design solutions. Besides the theoretical knowledge necessary to model aircraft, students will also learn the basics of programming language for numerical computations and software for aircraft design.

learning outcomes
Complete understanding of airplane structure and relationships among the elements. Understanding aerodynamics, flight mechanics, and propulsion group influence to aircraft design and the ability to apply this knowledge to the conceptual design of an aircraft. Understanding and specification of the manufacturing process and surface protection. Mastering the programming languages and software tools for the design of aircraft parts and assemblies.

theoretical teaching
Aircraft design procedures. Wing design characteristics. Design of tail surfaces. Fuselage design. Landing gear design. Application of modern aluminum alloys. Application of super-alloys. Connection of assembles and surface protection. Application of non-metallic materials in aeronautics. Jigs and fixtures. Surface modeling in MCAD software. Aeronautical standards. Materials designation. Heat treatment and surface protection. Composite materials. Documentation for composite materials. Ply and fabrics. Testing of composite materials. Tools for manufacturing aircraft parts. Heat treatment of composite materials. Tools for composite part production. Unidirectional composites. Rivet types and riveting. Riveted joints.

practical teaching
Practical exercises follow lectures illustrating them through applications. Students will learn how to use programming language for numerical computations which are necessary and how to use MCAD software. Students get skills within various workbenches od software. Modeling of parts, sheet metal parts, and drafting are covered. Students must design several aircraft parts using MCAD software. Their works are presented to colleges. Discussion of strong and weak points of the design takes place during presentations.

prerequisite
As defined by curricula of study program.

learning resources
SimLab facility, application VAZMFB (https://vazmfb.com).

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
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: 15
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): 30

references

A. Grbovic, M. Milos: Software Tools in Design, Faculty of Mechanical Engineering, Belgrade, 2017
Handouts

FEM Analysis

ID: BSc-0544
responsible/holder professor: Simonović M. Aleksandar
teaching professor/s: Dinulović R. Mirko, Peković M. Ognjen, Svorcan M. Jelena, Simonović M. Aleksandar
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: written+oral
parent department: aerospace engineering

goals
Understanding and mastering the process of solving engineering problems using finite elements method and modern software tools. Furthermore, the aim of this course is to develop personal and professional skills of the students along with the development of analysis methodology and solving engineering problems.

learning outcomes
After accomplishing the course,a student is capable of working in modern work environments. With learned skills student can implement his theoretical and practical knowledge in engineering practice, achieving a high degree of effectiveness. This knowledge encourages further improvement for students.

theoretical teaching
Theory: Introduction – modern design methods – software tools and advanced analisys techniques application – mathematical basis - an algorithmic concept of the finite element method - basics of matrix algebra – numerical analysis methods - mathematical interpretation of the finite elements - linear element – surface elements – volume elements - the design, analysis and solving engineering problems using finite element method (line elements) - the design, analysis and solving engineering problems using finite element method (surface elements) - the design, analysis and solving engineering problems using finite element method (volume elements)

practical teaching
Practice: mathematical foundations - numerical methods of analysis - the basics of matrix algebra - the mathematical interpretation of the finite element – solving engineering problems using FEM (linear elements) – solving engineering problems using FEM (surface elements) - solving engineering problems using FEM (volume elements) - a comparative analysis of the results obtained with finite element method and classical methods of calculation - the interpretation of results and verification of analysis results

prerequisite
Preferred: Attended and passed courses – Mathematics 1-3, Mechanics 1-3, Shape modeling, Strenght of material

learning resources
455, Computer Lab – Design in mechanical engineering module

CATIA V5 software package, Computer Lab – Design in mechanical engineering module

Simlab - computer laboratory

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
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: 15
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

M. Kalajdžić, "Finite Element Method ", IAMA Belgrade 1978., KDA(in Serbian)
Additional materials (written excerpts with the lectures, setting tasks, guidelines for solving the task), DVL
M. Sekulović, "Metod konačnih elemenata", IRO "Građevinska knjiga", Beograd 1988
Z. Petković, "Metalne konstrukcije u mašinogradnji 2", Mašinski fakultet, Beograd, 2005.
O.C.Zienkiewicz, R.L.Taylor, J.Z.Zhu, "The Finite Element Method: Its Basis and Fundamentals Sixth Edition", Elsevier, 2005.

Fundamentals of aerotechnics

ID: BSc-0630
responsible/holder professor: Petrović B. Nebojša
teaching professor/s: Bengin Č. Aleksandar, Grbović M. Aleksandar, Dinulović R. Mirko, Ivanov D. Toni, Mitrović B. Časlav, Petrović B. Nebojša
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: written
parent department: aerospace engineering

goals
The aim of this course is to introduce students to basic concepts in the field aerotechnics. The subject is presented in four integrated areas: aerodynamics, structures and construction, plant and equipment. In addition to popularize aviation, the aim of this course is to highlight the role of students in various fields aerotechnics mechanical engineering.

learning outcomes
After passing the subjects the students are expected to understand the basic concepts and problems in the field of aerodynamics, structures, construction, aircraft engines and aircraft equipment. In doing so, it is expected that the student able to recognize and apply these disciplines of aviation technology in other areas.

theoretical teaching
In the theoretical part analyzes the following topics: history of aviation, aircraft types (basic components and their role), the concept of aerodynamic forces, the notion of aerofoil (geometric and aerodynamic characteristics), different aerodynamic aircraft structural scheme: a mathematical model aircraft-core performance, analysis of mass , center of gravity, the notion Centraza; budget based aircraft structures, types of forces acting on the aircraft, the flight envelope, elementary calculations of aircraft parts (motor mount, nose leg); historical overview of aviation design, aviation design types, analysis of the construction costs of aviation; basic elements of stricture wings and fuselage, making Straka fuselage; types of facilities, historical development, basic concepts (traction and thrust force), piston-driven propeller, the impact position driveline, turbo-jet aircraft, rocket-powered aircraft; place and role equipment and systems, installation and basic aircraft systems, encoders, instruments and equipment (Historically the development of constructive solutions), role of computers in design, construction and maintenance.

practical teaching
In the practical part of teaching the short working computational tasks and analyze the concepts and examples of various constructive aerodynamic types solutions (different types of aircraft,vehicles, wind, etc.). Students operate using a virtual workshop on the internet in case they are registered in groups. Students, as part of their group, work of reference for a given aircraft, and the exercises are consulted about the form, scope and content of work. The paper presents representative of the group, in the last week of classes. Planned students excursions one of aviation organizations to familiar the real structures and systems used in aircraft.

prerequisite
without the conditions

learning resources
The work on the case is open a virtual shop on the Internet. MOODLE is used program. Students enrolling in the electronic workshop, a dress for the first time. In the workshop, students can access the professor notes, and additional material that advise the professor.

As part of the work on subject is open a virtual workshop on the Internet. MOODLE is used program. Students be registered in the electronic workshop, and be trained for the first class. Using MOODLE students can access the professor notes, and additional material that advise the professor.

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
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: 15
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: 40
final exam: 30
requirements to take the exam (number of points): 30

references

Introduction to engineering simulations

ID: BSc-0617
responsible/holder professor: Bengin Č. Aleksandar
teaching professor/s: Bengin Č. Aleksandar, Simonović M. Aleksandar
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: seminar works
parent department: aerospace engineering

goals
The students would be introduced to engineering simulations based on continuum mechanics. The students should acquire understanding of well posed problem through definition of boundary and initial conditions applied to certain physical phenomenon which characterize existence and uniqueness of the solution. Adoption of the specific type of additional conditions depending on the type of the problem, as well as selection of appropriate approximation for solution of the model problems would be presented to students. The students should gain skills for individual code development for model equations.

learning outcomes
By mastering the curriculum the student will gain sufficient theoretical knowledge necessary to identify the problem type, number and type of boundary conditions in order to define well posed problem which is simulated. The student will be able to identify basic schemes for calculation of problems of certain type. The basic principles of programming for simulation of continuum should be adopted by the student. The structure of simulation software which consist of preprocessing, simulation and visualization should be perceived by the student.

theoretical teaching
1. Introduction to engineering simulations in order to familiarize students with typical engineering problems 2. Fundamentals of numerical methods 3. Implementation of numerical methods for solving of engineering problems 4. Theoretical fundamentals for typical problems solving using complementary software tools

practical teaching
Exercises consist of three parts: introduction to work on Linux cluster, student registration and login and usage of commands for compilation, source code editing and visualization of the results. The second part of the exercises consist of practical demonstration of the methods presented in theoretical classes, where similar problems to problems for own student work are solved. The third component of the exercises is programming of the mentioned problems in order to complete the cycle of editing, compilation and result visualization process. The students are learned to present there work in general acceptable manner.

prerequisite
There aren't any compulsory conditions for course attendance.

learning resources
1. Linux cluster

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
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: 15
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

Light and Composite Structures

ID: BSc-1077
responsible/holder professor: Peković M. Ognjen
teaching professor/s: Dinulović R. Mirko, Peković M. Ognjen, Svorcan M. Jelena, Simonović M. Aleksandar
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: oral
parent department: aerospace engineering

goals
The goal of the course is to acquaint students with the properties of composite materials used for making aircraft structures, composite manufacturing technologies as well as the specifics of their implementation and exploitation in aeronautics.

learning outcomes
After completing the course, a student is familiar with the philosophy of design, manufacturing technologies and specifics of protection, exploitation and maintenance of composite aircraft structures. Acquired theoretical knowledge and practical skills, students can effectively apply in the construction of composite aircraft parts and their analysis. Within practical training students learn the basics of modern software packages intended for the modeling and calculation of composite parts.

theoretical teaching
- Overview of composite materials application in military and civil aviation
- Characteristics of composite materials. The characteristics of matrix and reinforcement (woven and continuous fibers). Characteristics of pre-preg materials. Specificity of sandwich constructions.
- Mechanics of Composite Materials
- Design of composite parts
- Production of composite parts - the integration of production processes and CAD
- Machining of composite structures; joining of composite parts.
- Damage of composite structures; classification of damage and methods of repairs
- Testing and certification of composite structures
- Trends and future applications of composite structures. New technologies of production.

practical teaching
Within lab exercises, the material exposed during theoretical lectures is expanded with concrete examples. Students gain experience in the use of modern engineering software, with an emphasis on shape modeling, material properties modeling and finite element analysis, which they can later use for solving real engineering problems.

prerequisite
No obligatory prerequisites.

Suggested attended and passed courses: Mechanics 1-3, Strength of materials

learning resources
1. Lecture materials (written excerpts of the lectures, problem formulations, guidelines for solving the problems), DVL

2. R.Jones,"Mechanics of Composite Materials, Second edition",Taylor and Francis,1999

3. A.Baker, S.Dutton,D.Kelly, "Composite Materials for Aircraft Structures, Second edition", AIAA,2004

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
auditory exercises: 0
laboratory exercises: 0
calculation tasks: 10
seminar works: 0
project design: 10
consultations: 10
discussion and workshop: 0
research: 0

knowledge checks: 15
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: 30
laboratory exercises: 0
calculation tasks: 0
seminar works: 30
project design: 0
final exam: 30
requirements to take the exam (number of points): 60

references

Reddy JN. Mechanics of laminated composite plates and shells theory and anlysis, 2ed. CRC Press, New York, USA (2004)

Mechanics of Flight

ID: BSc-0944
responsible/holder professor: Mitrović B. Časlav
teaching professor/s: Bengin Č. Aleksandar, Mitrović B. Časlav
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: project design
parent department: aerospace engineering

goals
The main objective of the course is to develop understanding of the mechanics of aircraft flight. Methods to assess and calculate the basic performance, stability, controlling and maneuverability of aircraft will be studied in the course.

learning outcomes
Having mastered the planned curriculum, the student acquires sufficient theoretical and practical knowledge to be able to estimate independently the performance possibilities of modern aircraft and any flight restrictions that arise from it. In this course, students will receive full sublimation and the verification of previously acquired knowledge and skills that they have required within the aviation modules from the group of aerodynamic subjects.

theoretical teaching
- Introduction.

- General definitions of flight mechanics.

- General characteristics of the power plant.

- Stationary flight condition aircraft performance.

- Special performances: takeoff, landing, range and flight duration.

- Horizontal flight.

- Powerless flight.

- Acrobatic flight maneuvers:

  * dive,

  * loop (looping),

  * combat turn,

  * inverted flying,

  * "knife-edge" maneuver,

  * Cuban eight,

  * turns, roll,

  * "Bell" maneuver,

  * "Cobra" maneuver,

  * Immelman turn,

  * stall and

  * spin.

- Fundamentals of stability and maneuverability of the aircraft.

- Fundamentals of flight tests.

practical teaching
Revision of aero properties of the atmosphere. International standard atmosphere. Measurement of the basic parameters of airflow in the wind tunnel. Measurement of basic parameters of the load model in the wind tunnel. Project assignment on the aircraft performance.

Tutorials follow the theoretical lectures.

prerequisite
No special conditions.

learning resources
Basic material: Č. Mitrović – Mechanics of Flight (handouts) and instructions for project assignment (handouts).

Additional material: Necessary material for lectures, tutorials, assignments, projects and term papers will be available to the students on the following website http://vaz.mas.bg.ac.rs/moodle .

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
auditory exercises: 0
laboratory exercises: 10
calculation tasks: 0
seminar works: 5
project design: 10
consultations: 0
discussion and workshop: 5
research: 0

knowledge checks: 15
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: 5
final exam: 0

assessment of knowledge (maximum number of points - 100)
feedback during course study: 10
test/colloquium: 15
laboratory exercises: 10
calculation tasks: 0
seminar works: 0
project design: 35
final exam: 30
requirements to take the exam (number of points): 35

references

Basic material: Č. Mitrović – Mechanics of Flight (handouts) and instructions for project assignment (handouts).
Z. Rendulić, Flight mechanics, Belgrade, VINC 1987
D.G. Hull, Fundamentals of Airplane Flight Mechanics, Springer
OXFORD:Book 6 - Flight Performance & Planning 1, Book 7 - Flight Performance & Planning 2, Book 13 - Principles of Flight
D.Cvetković, Flight mechanics - performance aircraft, Own edition, 2004

Structural Analysis of Flying Vehicles

ID: BSc-0945
responsible/holder professor: Petrašinović M. Danilo
teaching professor/s: Grbović M. Aleksandar, Dinulović R. Mirko, Petrašinović M. Danilo
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: written
parent department: aerospace engineering

goals
1. Introduction to problems and modern solution methods in stress analysis related to aircraft structures and their implementation in solving real structural problems.

2. Introduction to experimental stress analysis of aircraft structures.

3. Introduction to thin-walled structures and composite materials.

4. Introduction to computer modeling and simulation of aircraft structures.

learning outcomes
1. Mastering basic theoretical knowledge in structural analysis.

2. Application of acquired knowledge in solving real life problems.

3. Understanding the basic aircraft design principles.

4. Understanding the modern approach in solving structural problems in aircraft airframe design.

theoretical teaching
In the theoretical part the following topics are covered: aircraft loads, load coefficient, flight envelope, flight envelope for symmetric flight cases, gust loads, unsymmetrical loading conditions, landing gear loads, engine mount loads and stress analysis, wing skin, sing skin buckling, normal and shear stress calculation, effective width, wing stress analysis, wing spar analysis, wing-fuselage rib connection analysis, design solutions, delta wing stress calculation, fuselage stress strain calculation methods, pressurized cabin calculation, stress analysis in the vicinity of openings, fuselage rib calculation, finite element method applied to airframe structural analysis, structure idealization, composite material stress calculation, static and dynamic testing and testing equipment design, apparatus and techniques in experimental stress analysis.

practical teaching
During the practical part of the course theories related to aircraft stress analysis are applied to real problems. Numerical examples are analyzed. Practical student work is realized through mandatory exercises and design project realization using computer software for modeling and analysis. Professor lecture notes, solved past exam papers are at student's disposition. Practical part of the course also includes visit to the VTI technical institute.

prerequisite
no special requirements

learning resources
Lecture notes in e-format, media films and computer simulation models, Internet resources, application VAZMFB (https://vazmfb.com).

number of hours: 75

active teaching (theoretical): 30
lectures: 20

elaboration and examples (revision): 10

active teaching (practical): 30
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: 15
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

Structural and Stress analysis, T.H.G Megson
Structural Analysis, Hibbeler Russell C.

Theory of Elasticity

ID: BSc-0539
responsible/holder professor: Dinulović R. Mirko
teaching professor/s: Dinulović R. Mirko, Simonović M. Aleksandar
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: written+oral
parent department: aerospace engineering

goals
1. Introduction to stress analysis related to aircraft structures and it's application to practical airframe sizing and stress analysis.

2. Introduction to Experimental stress-strain analysis of airframe structures

3. Introduction to thin-walled constructions and composite material constructions

4. Introduction to modern numerical stress analysis applied to aircraft constructions, analysis and performance

learning outcomes
In the end of the course, students should be able to:

1. Calculate the stress-strain state of thin-walled metallic structure in the linear domain for a preset load.

2. On the basis of a calculated stress strain state, dimension main parts of aircraft structure such as wing skins, spar webs, spar caps, wing ribs, fuselage frame and stringers.

3. To effectively use commercial software for structural analysis based on finite element method.

4. Generate finite element models of parts of aircraft structures and perform structural analysis

theoretical teaching
During theoretical part of the course, following topics are covered: Material and space coordinates. Equilibrium eqations. Compatibility conditions. Boundary conditions. Elastic behavior of materials. Plane strain. Plane stress state. Mathematical methods in solving these problems. Force method. Displacement method. Cross section warping. Exact solutions for axial, bending and torsion problems for loaded elastic bodies. Plates and Shells. Shear stress analysis. Composite Plates. Lamina and Laminate. Sandwich composite structures. Interlaminar stresses. Failure criteria applicable to composite materials. Variational methods. Method of virtual work. Potential energy minimum principle. Rayleigh -Ritz principle. Galerkin method. Colocation mathod. Finite elemnet method formulation. covergence conditions. Beam and rod finite element formulation. Stiffness matrix and equivalnet nodal force matrix.

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: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
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: 15
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): 21

references
Structural and Stress analysis, T.H.G Megson
Elasticity, Chou and Pagano

Windturbines

ID: BSc-1075
responsible/holder professor: Simonović M. Aleksandar
teaching professor/s: Ivanov D. Toni, Peković M. Ognjen, Svorcan M. Jelena, Simonović M. Aleksandar
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: oral
parent department: aerospace engineering

goals
Throughout this course student will learn about the principles, components and design of wind turbines, as well as regulation and dynamic balancing of the system. Acquiring the knowledge necessary for wind turbine blade design based on the aerodynamic and structural criteria, performance computation (power, coefficient of power, torque, aerodynamic characteristics of blades), calculation based on similarity theory and the topology definition of wind energy systems is the main aim of the subject.

learning outcomes
Mastering the curriculum the student receives the following subject-specific skills:

-thorough knowledge and understanding of different concepts of wind turbines 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 overview of wind turbines;

- Components of wind turbines – analysis and design of rudimentary assemblies;

- Wind characteristics

- Dimensioning of wind turbine blades – Betz theory, aerodynamic forces on rotating blades, the losses;

- Calculation of characteristics;

-Structure and blade load;

- wind turbines similarity theory- application and limitations;

- pumps driven by wind- possibilities of application, types, coupling of wind turbines and pumps, sizing;

-wind turbine electrical system- main concepts, types of generators, accumulation of electrical energy, systems connected to public grid, losses in energy transmission system;

- Regulation of wind turbines;

- The dynamics of wind turbines - the oscillations in the system, modeling of oscillations;

- Off-shore wind turbines - requirements, types of off-shore wind turbines, foundations and structure of the types of off-shore wind farms, maintenance

- The construction of wind turbines

practical teaching
- Presentation of various wind turbine designs

- Basic parts of the system

- Devices for the wind speed measurements - anemometers

- Dimensioning of the blades - a numerical simulation of the flow around airfoils and blades dimensioning

- Performance calculations - the development and application of existing software for the calculation of characteristics of wind turbines

- Analysis of the stress - strain state of turbine rotor blades

- Static testing of blades

- Dynamic testing of blades

- Configuration of wind energy systems

prerequisite
There are not any compulsory conditions for course attendance.

learning resources
1. Pesic S., Wind energy - Aerodynamics wind energy system with a horizontal axis rotor, Faculty of Mechanical Engineering, 1994., KDA(in serbian)

2. Petrović Ž. Stupar S., Computer design, Faculty of Mechanical Engineering, 1992, KPN(in serbian)

3. Additional materials (written performed with the lectures, setting tasks, guidelines for solving the task), DVL

4. 452, Computer Laboratory SimLab, ICT / CAH / KLR

5. FORTRAN, Computer Laboratory SimLab, ICT / PPO

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
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: 15
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

1. Pesic S., Wind energy - Aerodynamics wind energy system with a horizontal axis rotor, Faculty of Mechanical Engineering, 1994., KDA(in serbian)

AGRICULTURAL ENGINEERING

Drying and hygrothermal processes

Renewable and secondary resources

Drying and hygrothermal processes

ID: BSc-1364
responsible/holder professor: Zlatanović J. Ivan
teaching professor/s: Zlatanović J. Ivan
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: written+oral
parent department: agricultural engineering

goals
Introduction to theoretical foundations, technical and technological data in the field of drying and hygrothermal processes, which are needed by engineers for rational use of energy, design of appropriate solutions and efficient implementation of processes and operation of devices and plants, which includes development of creative abilities and mastery of specific practical skills. performing work tasks.

learning outcomes
Upon successful completion of this course, students should be able to: 1. Define the basic drying processes; 2. Describe the processes related to moist air and wet material; 3. Describe and distinguish the processes and parameters of drying and storage of different agricultural crops; 4. Compare the use of alternative energy sources with conventional drying procedures; 5. Applications of the basis of the calculation of the plant for drying agricultural products.

theoretical teaching
1.0. Physico-chemical basis of the drying process: Wet gas (air); Wet material; Statics of the drying process. 2.0. Fundamentals of the theory of energy and moisture transfer in the drying process; Kinetics of the drying process; Combined process of heat and matter transfer in the drying process. 3.0. Basics of drying technique: Basic methods of moisture separation: Basic methods of thermal drying. 4.0. Brief overview of drying plants and basics of engineering calculation: Classification and brief overview of drying plants; Basics of drying plant calculation. 5.0. Thermophysics of production facilities. 6.0. Heat application on farms and livestock complexes: Microclimate in livestock and poultry facilities. 7.0. Facilities with protected space. 8.0. Technological bases of product storage; Storage conditions, storage types and storage methods. 9.0. Use of low temperatures in agricultural production: Physical essence and methods of cooling. 10.0. Economics of thermal energy resources and thermotechnical indicators: Use of renewable energy sources; Use of secondary energy resources; Improving the construction of the ventilation system and increasing the thermal resistance of the walls.

practical teaching
Practical classes: Preparation of seminar papers from some of the theoretical units, in order to get acquainted with the existing solutions, their characteristics and monitor the achievements in the field; Creating computational tasks. Laboratory exercises: 1.0. Determination of moisture content of wet materials.2.0. Determination of physical and mechanical characteristics of biological materials (porosity, friction angle).

prerequisite
Defined by the study program / module curriculum.

learning resources
1. Топић M. Radivoje, Osnove projektovanja, proračuna i konstruisanja sušara, Nauchna knjiga, 1989, Belgrade, KPN, 2. Topić M. Radivoj, Bogner Martin, Tehnika sušenja, Zavod za ujbenike i nastavna sredstva, 2002., Beograd KPN, 3. Laboratorijska instalacija za izvođenje laboratorijske vežbe, LPI; 4. Топић M. Radivoj, Drying and Hygrothermal Processes (printed materials for the Handouts lecture). Example of completed projects and seminar papers. Various instructions and standards.

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
auditory exercises: 0
laboratory exercises: 5
calculation tasks: 10
seminar works: 0
project design: 10
consultations: 0
discussion and workshop: 0
research: 5

knowledge checks: 15
check and assessment of calculation tasks: 5
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: 0

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): 50

references

Топић, Р.: Сушење и хигротермички процеси, Машински факултет у Београду, 2013.
Филоненко К. Г., Гришин А. М., Гольденберг М. Я., (1971) Сушка пищевых растительных материалов, "Пищевая промышленность" , Москва.
Лыков В. А., (1950), Теория сушки," Государственное энергетическое издательство", Москва - Ленинград.
Arun S. Mujumdar: HAndbook of industrial drying, 3rd. ed., CRC Press, 2006.
Xiao Dong Chen, Arun S. Mujumdar: Drying Technologies in Food Processing, Blackwell publishing, 2008.

Renewable and secondary resources

ID: BSc-1363
responsible/holder professor: Zlatanović J. Ivan
teaching professor/s: Zlatanović J. Ivan
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: project design
parent department: agricultural engineering

goals
Introduction to the theoretical foundations, technical and technological data needed by engineers for rational use of energy, design of appropriate solutions, and efficient implementation of processes and operation of devices and plants for the useful valorization of renewable and secondary energy sources, including the development of creative abilities and mastery of specific practical skills. performing work tasks.

learning outcomes
Upon successful completion of this course, students should be able to:

• Describe and distinguish between types of renewable and secondary resources,

• Recognize the prerequisites for the application of a particular energy source,

• Assess the energy efficiency of the application of a particular energy source in the given conditions,

• Compare energy sources,

• Discuss the possibilities of alternative energy supply,

• Select appropriate machines and equipment for functional supply of facilities.

theoretical teaching
1.0. General remarks: Global energy aspect; Energy and forms of energy; Renewable energy. 2.0.Solar energy: Solar radiation; Solar energy receivers. 3.0. Wind energy: Wind energy and its significance; Wind speed and energy potential; Wind turbines and their characteristics; Division of wind motors according to the place of performance and power values; Advantages and disadvantages of different types of wind turbines.4.0. Biogas: Anaerobic fermentation; Biogas plant components, processes and characteristics; Types of digesters of biogas production plant systems. 5.0. Biomass: What is biomass; Biomass energy; Methods of obtaining energy from biomass; Reasons and advantages of using biomass; Demonstration of the solution concept of a plant for high-temperature sawdust drying. 6.0. Heat pumps: Characteristics and principle of operation of heat pumps; Thermodynamic characteristics of heat pump cycles; Heat sources and purpose of heat pumps; Heat pump systems for the use of different energy sources. 7.0. Energy from the environment; Geothermal energy; Hydrogen energy; Fuel cells. 8.0. Use of gravitational field energy; Use of energy mena; Using wave energy. 9.0. Use of secondary energy resources.

practical teaching
Simulation of solar systems. Testing of indirect solar dryer at a laboratory plant in the Department of Agricultural Engineering in order to define the drying kinetics of biological materials, which includes measuring the mass and temperature of material samples at certain times, as well as measuring the intensity of solar radiation and drying agent parameters; .Calculations are made in order to define and dimension characteristic solutions from some of the theoretical units. Visits to the facilities in order to get acquainted with the implemented solutions for the use of renewable energy sources (heat pumps, windmills, solar power plants, solutions for useful valorization of biomass, etc ..

prerequisite
Defined by the study program / module curriculum.

learning resources
1.Labudović Bopis, Renewable energy sources, Energetika marketing, 2002.KDA 2. Topić R. Jelena, (2005), Technologies and systems for the use of solar energy, graduate thesis, Belgrade 3. Topić M. Radivoj, Renewable and Secondary Resources (for teaching Handouts). Example of a report on laboratory exercises. Various instructions and standards.

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
auditory exercises: 0
laboratory exercises: 5
calculation tasks: 10
seminar works: 0
project design: 10
consultations: 0
discussion and workshop: 0
research: 5

knowledge checks: 15
check and assessment of calculation tasks: 5
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: 0

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): 50

references
Топић, Р.: Обновљиви и секундарни ресурси, Машински факултет у Београду, 2013.
Volker Quaschning: Understanding renewable energy systems, Earthscan, London, 2005.
Jonathan R. Mielenz: Biofuels: Methods and Protocols, Humana Press, 2009.
Гојак, М., Рудоња, Н: Соларни термички системи, Машински факултет у Београду, 2020.
Dan E. Arvizu: The Growing Significance of Renewable Energy - Lectures, National Renewable Energy Laboratory, USA, 2007.

BIOMEDICAL ENGINEERING

Fundamentals of Clinical Engineering

Fundamentals of Clinical Engineering

ID: BSc-1272
responsible/holder professor: Matija R. Lidija
teaching professor/s: Matija R. Lidija
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 2
final exam: written
parent department: biomedical engineering

goals
Introduction to clinical engineering based on examples (high-quality application of medical technologies and information technologies, quality assurance, implementation of "good medical practice" etc.). Introduction to medical technologies which heavily rely on clinical engineers (i.e. medical imaging, radiation protection, rehabilitation, use of robots, etc.).

General introduction to medical equipment. Basics of medical equipment design and maintenance (surgical tables, beds, chairs, etc.).

Introduction to medical device maintenance. Introduction to legislation regarding medical device design and maintenance. Maintenance of concrete devices.

Basics of medical device maintenance.

learning outcomes
Upon successful completion of this course, students will be able to:

•To adopt and differentiate operating principles in a clinical setting (ethics, standards, information technology)

•To describe the main characteristics and design of the medical devices and define their appropriate applications

•To master the design process of medical devices, from the initial idea to the final realization, and manage project planning, project flow and project budget

theoretical teaching
Good practices regarding work in clinical environment. Ethics, standards and IT. Concept and basic characteristics of medical device. Medical device vs medical equipment. History of medical devices development. Connection between advances in science and development of biomedical apparatus. Medical device classification. Hospitalization and associated medical instrumentation.

Medical imaging – clinical applications (benefits, protection and potential hazards). DICOM standard. Endoscopy. Radiography and Computed Tomography. Gamma camera and SPECT. MRI and fMRI. Sonography. NIRS. Body termography.

Maintenance definition. Legislation regarding medical device and equipment maintenance. Maintenance organization and planning. Precautions regarding medical device maintenance. Adequate working environment and prerequisites for medical device maintenance. Maintenance of various devices and equipment.

Process and design stages of a medical device from an idea to a final product . Literature review: patent survey, marketing survey, setting up the requirements of the application, properties of the components of the device studied. Setting up the schedule, work flow and budget for the project.

practical teaching
Application of gamma camera and PET (at the Clinical Center of Serbia). Ultrasound applications in medicine (at the MMA). Measurement of temperature distribution (in the laboratory).

Preparation of material for obtaining a license to use a new clinical equipment/device.

Basics of operation and maintenance of a variety of devices at the Institute for Cardiovascular Diseases "Dedinje".

prerequisite
Requirements for attending are defined with curriculum of study program/module.

learning resources
1. Written course material (handouts).

2. Printed manuals.

number of hours: 30

active teaching (theoretical): 12
lectures: 8
elaboration and examples (revision): 4

active teaching (practical): 12
auditory exercises: 0
laboratory exercises: 8
calculation tasks: 0
seminar works: 0
project design: 3
consultations: 1
discussion and workshop: 0
research: 0

knowledge checks: 6
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: 2
final exam: 1

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: 30
final exam: 35
requirements to take the exam (number of points): 35

references
Barbara L. ChristeI: Introduction to Biomedical Instrumentation. Cambridge University Press, 2009.
Myer Kutz (Ed.): Biomedical Engineering and Design Handbook, 2. ed. McGraw-Hill, 2009.

CONTROL ENGINEERING

Fundamentals of control engineering

Fundamentals of control engineering

ID: BSc-0041
responsible/holder professor: Lazić V. Dragan
teaching professor/s: Jovanović Ž. Radiša, Lazić V. Dragan, Ribar N. Srđan
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: written
parent department: control engineering

goals
Introduction to basic concepts in the field of Automatic Control and training for implementation and verification of acquired knowledge to specific physical systems and processes.

Acceptance of some methodologies for analytical and experimental verification of the basic static and dynamic characteristics and parameters of the system.

Learning basic MATLAB tools to help in calculation and simulation of all of the computational parts of this subject.

learning outcomes
Getting basic knowledge of the automatic control.

Identify and use the methods needed for analysis and synthesis of the controllers as a part of the control system, as well as the whole automatic control system.

For proper use of computers and MATLAB in solving the main problems of the control systems, as well as other engineering problems.

To be analytical and / or experimentally investigated the basic dynamic and static characteristics of the system

theoretical teaching
Introduction to basic concepts and terms in the field of the automatic control. Basic concepts of the automatic control. The control systems of basic physical values (position, level, pressure, flow, temperature, speed, ...) illustrated the most frequent objects and processes in mechanical engineering. The basic dynamic and static characteristics and parameters of the system in time domain, their analytical determination (time constant, rise time, settling time, overshoot, gain, static error, ...). The transfer function of the system. Block diagrams. Frequency response of the system. The main indicators of the system in the domain of frequency response (resonance frequency, attenuation, bandwidth, ...). The basic types of control systems: P, PI, PID and their impact on the dynamic and static properties of the system through the commonly used objects and processes in mechanical engineering. The concept of stability criterion for the stability checking of linear systems.

practical teaching
Practical training shall include all the above experimental methods, and training is based on simulation using MATLAB.

Presentation of the systems and physical values by the standard symbols, labels and understanding of control principles based on design documentation.

Experimental evaluation of the main system parameters in the time domain (time constant, rise time, settling time, overshoot, gain, static error, ...).

The transfer function, experimental determination and significance.

Frequency response of the system, the experimental determination and significance. Hydraulic servo systems, servo valves, hydraulic cylinders.

prerequisite
Basic computer knowledge founded on PCs platforms, basic knowledge of higher education mathematics.

learning resources
• Literature on the website http://dragan.lazic.bakpakddns.com:8888 - Moodle

• Licensed Software in the possession of faculties.

• Freeware software.

• PCs.

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
auditory exercises: 9
laboratory exercises: 0
calculation tasks: 10
seminar works: 0
project design: 0
consultations: 2
discussion and workshop: 5
research: 4

knowledge checks: 15
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: 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): 20

references
Ljubomir Grujic, Dragan Lazic, "INTRODUCTION TO AUTOMATIC CONTROL", Script, Faculty of Mechanical Eng., 2007
Dragan V. Lazic, Milan R. Ristanovic, "INTRODUCTION TO MATLAB", Faculty of Mechanical Eng., 2005

ENGINEERING MATERIALS AND WELDING, TRIBOLOGY, FUELS AND COMBUSTION

Combustion and sustainable development B

Combustion B

Engineering Materials 1

Engineering materials 2

Fuel, Lubricants and Industrial Water

Tribology

Tribotechnique

Combustion and sustainable development B

ID: BSc-1034
responsible/holder professor: Milivojević M. Aleksandar
teaching professor/s: Milivojević M. Aleksandar
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: written
parent department: engineering materials and welding, tribology, fuels and combustion

goals
In light of the fact that currently over 90% of world energy demand is satisfied by combustion processes, and that in the coming decades is projected that combustion will be the predominant technology, with a share of over 65%, this course is designed, keeping in mind the main goal is to introduce students in the area of the problems of sustainable development and energy, to provide better understanding, accept the findings and enable it to competently participate in its resolution.

learning outcomes
After completion of this course students should be able to:

- overview of the current and future challenges posed by the new scenario of the problem of energy efficiency and sustainable development,

- use and apply combustion technology in existing and future energy systems and technologies,

- apply acquired knowledge in this field in the industry and energy sectors,

- work in research and development organizations.

theoretical teaching
The problem of energy. Energy sources.

Fossil fuels, renewable energy sources, industrial and municipal waste.

Environmental aspects - pollution of air, water and land.

Basics of the combustion processes.

Material and energy balances.

Specifics of burning different types of fuel.

The impact on the environment.

The concept of sustainable development.

Complex systems.

Sustainable development in terms of the developed countries.

Specifics for developing countries.

Energy processes and devices based on combustion.

New technologies.

practical teaching
Practical training shall include practical exercises, laboratory exercises, computational tasks and seminars.

Within auditory exercises will be done more examples of material and energy balance of the combustion process and pollutants, as well as the explanation of the principle of measuring emissions of combustion

products. Laboratory classes will include measurements of emissions of polluting components from the combustion process. In the framework of the computational task, students will do an individual task in connection with the material and energy balance of a combustion fuel. Seminar will cover the analysis of the introduction of alternative energy sources, more favorable from the standpoint of sustainable development in a particular energy device or process.

prerequisite
None.

learning resources
Handouts.

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
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: 15
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
Principles of Combustion (Принципи сагоревања), Kenneth K. Kuo, BARNES & NOBLE

Combustion B

ID: BSc-0968
responsible/holder professor: Jovanović V. Vladimir
teaching professor/s: Jovanović V. Vladimir, Manić G. Nebojša, Stojiljković D. Dragoslava
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: oral
parent department: engineering materials and welding, tribology, fuels and combustion

goals
Fuel types. Stoichiometric combustion equations. Combustion temperature.

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. Environmental aspects of combustion.

learning outcomes
Upon completion of this course, students should be able to:

1 Define the concept of fuel, the criteria for the characterization of fuel and fuel type according to the adopted criteria.

2 Calculation of the amount of the combustion products, their composition and the to calculate combustion temperature.

3 Perform the material and energy balance of the combustion process.

4 Define the basic concepts for the characterization of flame, the criteria for the flame characterization and the flame types according to the adopted criteria.

5 Determine the basic characteristics of the fuel in laboratory conditions: moisture content, mineral content, volatiles content, carbon residue content, heating value.

6 Determine the basic flame characteristics in the laboratory: laminar flame length, stable combustion limits, the ignition limits of and linear flame speed.

theoretical teaching
Fuel and combustion basics. The quantity and composition of combustion products. Combustion temperature. Fundamentals of thermodynamics of the combustion process, general terms, material and energy balance processes. 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. Specific features of combustion of solid, liquid and gaseous fuels. Environmental aspects of combustion. The causes, mechanisms of toxic components and the possibilities for prevention.

practical teaching
Calculation of heating value of fuel. Elements of stoichiometry. Combustion temperature. Determining the characteristics of proximate analysis of solid fuels. Determination of the 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. Dissociation products of combustion. Determination of the dissociation temperature of combustion. Incomplete combustion. Length of the laminar flame. The boundaries of stable combustion. Ignition limits (concentrations). Flame front propagation speed.

prerequisite
No special requirements for attendance the course.

learning resources

-

number of hours: 75

active teaching (theoretical): 30
lectures: 30
elaboration and examples (revision): 0

active teaching (practical): 30
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: 15
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

Engineering Materials 1

ID: BSc-0883
responsible/holder professor: Radaković J. Zoran
teaching professor/s: Bakić M. Gordana, Đukić Z. Miloš, Popović D. Olivera, Prokić-Cvetković M. Radica, Radaković J. Zoran
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 2
final exam: written+oral
parent department: engineering materials and welding, tribology, fuels and combustion

goals
After successfully attending the course, consisting of theoretical lectures on Engineering Materials 1, as well as maximal commitment in the practical topics of the course (through laboratory and problem solving exercises), the students become competent in the fundamentals of engineering materials, thus acquiring certain academic skills. By developing creativity and mastering specific skills that are necessary in the field of mechanical engineering, the students will gain an understanding of the structure of materials, their properties, applications and the possibilities for processing and altering their chemical, physical and technological properties.

learning outcomes
Upon the successful completion of the course, students are able to:

• Identify the type of chemical bonding, crystal structure, and properties for a given type of material (metal, ceramic, polymer)

• Apply information on elastic and plastic deformation for predicting the loads or strain, that lead to yielding, ultimate strength, or fracture. Differentiate the characteristic stress–deformation in metals, ceramics, crystals and non-crystals, polymers

• Identify common defects in materials, when do they occur, and how they influence the mechanical characteristics of materials

• Recognize the mechanisms that alter the mechanical properties of materials (deformation hardening, solid solution and precipitation hardening, …)

• Identify phases and concentrations, eutectic, eutectoid alloys and reactions on phase diagrams of solid state components – with complete and partial solubility, and components with the absence of solubility, and recognize simple microstructures and their influence on mechanical properties of materials

• Perform experiments (standard destructive tests) from which they analyze and interpret results of mechanical tests (hardness, plasticity, toughness, material resistance and deformation) on standard devices and machines (devices for measuring hardness by static and dynamic load, tensile testing machines, Charpy pendulum, extensometers, …)

• Select the material type for the given system, component or process, as to satisfy the loading and functionality criteria, from the aspects of the structure, property, technology and process

• Recognize the types of damage in engineering materials, their application and behaviour in exploitation (fatigue and creep), the classification and specifics of certain groups of modern materials used in mechanical engineering applications

• Apply the concepts of crack propagation and brittle fracture, as well as the ductile-to-brittle transitional effects in the goal to predict the fracture of brittle materials

theoretical teaching
Introduction. Engineering materials, classification, metals, ceramics, glass, polymers, composites. Material properties: mechanical, electrical, magnetic, optical. Material processing - general terms. Chemical bonding types. Crystalline and amorphous structures. Melting temperature. Softening. Crystalline structure of metallic materials, types of crystal lattices. Defects in crystal structures, point, linear, interfacial, and volume defects, and their importance. Plastic deformation. Diffusion. Fracture terms in general. Theoretical cohesive strength of metals. Basic elements in fracture mechanics. Fracture toughness. Transition temperature. Types of fracture, brittle, ductile. Basic terms in the theory of alloys. Pure metals. Solid solutions. Interstitial solid solutions. Substitutional solid solutions. Intermediate compounds. Eutectic reactions. Cooling curves. Characteristics. Basic types of phase diagrams.

practical teaching
Unit cell. Miller indices of planes and directions. Structure of ceramics, polymers. Behaviour of materials in the state of mechanical loading. Stress - deformation: metals, ceramics, polymers. Elastic deformation. Plastic deformation. Tensile testing. Pressure testing. Module of elasticity. Hardness, methods, based on static and dynamic loading, testing in laboratory conditions. Toughness, impact testing. Fatigue of materials. Technological testing. Creep. Non-destructive testing of materials. Phase diagrams of alloys - binary isomorphous systems with complete solid solubility. Phase diagrams of alloys - binary systems with intermediate phases/compounds. Phase diagrams of alloys - binary eutectic systems with limited solid solubility. Characteristics and applications.

prerequisite
Basic knowledge of mathematics, physics and chemistry.

learning resources
1. Prokić-Cvetković, R., Popović, O.: Engineering Materials 1, University of Belgrade, Faculty of Mechanical Engineering, 2012. (in Serbian)

2. Lecture handouts, documents to download from the web at http://afrodita.rcub.bg.ac.rs/~rzoran (in Serbian)

3. Prokić-Cvetković, R., Radaković, Z., Bakić, G., Popović, O., Đukić, M.: Engineering Materials, a manual for laboratory exercises, I part, University of Belgrade, Faculty of Mechanical Engineering, 2019. (lab. workbook, in Serbian)

4. Đorđević, V., Vukićević, M.: Engineering Materials, Practicum for exercises – part one, University of Belgrade, Faculty of Mechanical Engineering, 1998. (in Serbian)

5. Đorđević, V.: Engineering Materials – part one, University of Belgrade, Faculty of Mechanical Engineering, 1999. (in Serbian)

6. Šiđanin, L.: Engineering Materials 2, University of Novi Sad, Faculty of Technical Sciences, 1996. (in Serbian)

7. Callister, W.D., Rethwisch, D.G.: Materials Science and Engineering: An Introduction, 8th Ed., Wiley and Sons, 2010.

number of hours: 30

active teaching (theoretical): 15
lectures: 13
elaboration and examples (revision): 2

active teaching (practical): 10
auditory exercises: 4
laboratory exercises: 4
calculation tasks: 1

seminar works: 0
project design: 0
consultations: 1
discussion and workshop: 0
research: 0

knowledge checks: 5
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: 2
test, with assessment: 0
final exam: 2

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 15
laboratory exercises: 10
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 70
requirements to take the exam (number of points): 30

references

Prokić-Cvetković, R., Popović, O.: Mašinski materijali 1, izdanje Mašinskog fakulteta Univerziteta u Beogradu, 2012.
Prokić-Cvetković, R., Popović, O.: Mašinski materijali 1, izdanje Mašinskog fakulteta Univerziteta u Beogradu, 2012.
Đorđević, V., Vukićević, M.: Mašinski materijali, praktikum za vežbe – prvi deo, izdanje Mašinskog fakulkteta Univerziteta u Beogradu, 1998.
Šiđanin, L.: Mašinski materijali 2, FTN, Novi Sad, 1996.
Callister, W.D., Rethwisch, D.G.: Materials Science and Engineering: An Introduction, 8th Ed., Wiley and Sons, 2010.

Engineering materials 2

ID: BSc-0884
responsible/holder professor: Prokić-Cvetković M. Radica
teaching professor/s: Bakić M. Gordana, Đukić Z. Miloš, Popović D. Olivera, Prokić-Cvetković M. Radica, Radaković J. Zoran
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
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 Engineering materials 2. 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
Upon the successful completion of the course, the students are able to:

- Understand the dependence between microstructure, Fe-Fe3C and Fe-C phase diagrams, and the mechanical properties of the material
- Differentiate between steels and irons and define the fields of their application
- Select the proper heat- or chemical treatment, based on the required properties of the steel
- Define the characteristics and application of light and non-ferrous metals and alloys (Al, Cu, Ni, Ti, ...)
- Understand the conventional welding techniques
- Differentiate between the conventional welding techniques
- Apply the proper welding procedure for the given material

theoretical teaching
Metastable and stable phase diagrams of Fe - C. Steel and types of steel. Cast irons. Heat treatment of steel - annealing, quenching and tempering. Case hardening treatments: carburization, nitriding, carbonitriding, diffusion metalization. Non-ferrous alloys – aluminium, its alloys and their heat treatment. Nickel based alloys. Titanium based alloys. Hardfacing alloys. Introduction to welding. Electric arc. Arc welding. Manual metal arc welding (MMA). Gas metal arc welding (MIG - Metal Inert Gas and MAG – Metal Active Gas), gas tungsten arc welding (TIG – Tungsten Inert Gas), submerged arc welding. Oxyfuel welding and cutting. Resistance welding.

practical teaching
Cooling curves. Determination of the composition and fraction of the phases (lever rule). TTT and CCT diagrams and their application. Aloyed steels. Light microscopy and misrostructure. Heat treatment of steel. Steel marking. Material defects and their identification. Hardenability. Jominy end-quench method. Heat treatment of aluminium alloys-quenching and ageing. Mechanical testing od welded joints. Preparation of materials for welding. Technics and technology of arc welding. Technics and technologies of inert gas metal arc welding, shielded metal arc welding, tungsten arc welding, submerged arc welding. Technics and technologies of oxifuel welding and cutting. Resistance welding and methods. Welding Laboratory practice - electric arc welding, oxyfuel welding and cutting, resistance welding. Tests and Office hours.

prerequisite
Necessary conditions for a student to attend this course are: attended course lectures and finished exercises of Engineering materials 1.

learning resources
1. A.Sedmak, V. Šijački Žeravčić, A. Milosavljević, V. Đorđević, M. Vukićević, Mašinski materijali, drugi deo, Mašinski fakultet, Beograd, 2000

2. V. Đorđević, Mašinski materijali, Mašinski fakultet, Beograd,1999

number of hours: 75

active teaching (theoretical): 20
lectures: 20
elaboration and examples (revision): 0

active teaching (practical): 40
auditory exercises: 14
laboratory exercises: 24
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 2
discussion and workshop: 0
research: 0

knowledge checks: 15
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: 6
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): 40

references
W. Callister, Materials Science and Engineering, John Wiley & Sons, Inc., 2007.

Fuel, Lubricants and Industrial Water

ID: BSc-0054
responsible/holder professor: Stojiljković D. Dragoslava
teaching professor/s: Jovanović V. Vladimir, Manić G. Nebojša, Stojiljković D. Dragoslava
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
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, proximate and elemental analysis. Solid fuel origins, derivation, applications. Liquid fuels, origins, derivation, applications. Gaseous fuels, origins, derivation, applications. Lubricants, types and main characteristics, derivation, applications. Industrial water, types and properties. Essential characteristics of the water for use in 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 and preparation for use in industrial purposes.

theoretical teaching
Fuel and combustion basics. The quantity and composition of combustion products. Combustion temperature. 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 use for industrial purposes.

practical teaching
The conversion from one to another mass of solid fuel. Calculation of heating value of fuel. Elements of stoichiometry. Combustion temperature. Determination of the characteristics of proximate analysis of solid fuels. Determination of the heating value of solid and liquid fuels with a bomb calorimeter and the determination of the 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: 75

active teaching (theoretical): 30
lectures: 30
elaboration and examples (revision): 0

active teaching (practical): 30
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: 15
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

Tribology

ID: BSc-0517
responsible/holder professor: Vencl A. Aleksandar
teaching professor/s: Vencl A. Aleksandar
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
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:

• Identifies and critically analyze the basic causes of energy and material dissipation in some mechanical system;

• Recognize the dominant type of wear in some mechanical system and to propose appropriate measures for its reduction;

• Choose the appropriate type of material for the basic tribological elements (plain bearings, roller bearings and gears);

• Describes and distinguishes the most common surface modification and coating deposition methods;

• Explain the influences of temperature and pressure on the value of the viscosity (lubricants rheology);

• Describes and distinguishes the basic types and methods of lubrication with their characteristics.

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.

• Tribological materials (types and application in tribology); Characteristics and selection of materials for tribological components.

• Technologies for improving the tribological properties of materials (surface modifications and coatings).

• 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).

• Examples of different solutions for improving the tribological properties of materials.

• Laboratory practice: "Experimental evaluation of roughness, friction and wear"; Measuring of roughness and coefficient of friction and wear values for different materials and test conditions.

• Classifications and specifications of lubricants; Methods for lubricants testing.

• Laboratory practice: "Experimental investigation of the rheological properties of lubricants"; Determination of the rheological properties of lubricating oils (viscosity, viscosity-temperature dependence, viscosity index) and greases (shear stress and shear rate gradient, apparent viscosity).

• Essay writing.

prerequisite

No special requirements.

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. Viscometer for liquid lubricants; Pressure grease viscometer.

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
auditory exercises: 0
laboratory exercises: 12
calculation tasks: 0
seminar works: 5
project design: 0
consultations: 13
discussion and workshop: 0
research: 0

knowledge checks: 15
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: 0
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: 10
calculation tasks: 0
seminar works: 10
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: BSc-0371
responsible/holder professor: Vencl A. Aleksandar
teaching professor/s: Vencl A. Aleksandar
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
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;

• Describes and distinguishes types of liquid, semi-liquid, gaseous and solid lubricants and their basic characteristics;

• Choose the appropriate lubricant and method of lubrication for the basic machine elements and mechanical systems;

• 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.

• Forms and types of lubrication; Hydrostatic, hydrodynamic, elastohydrodynamic and boundary lubrication.

• Lubrication systems (tasks and roles; procedures and classification; elements definition); Selection of lubricants and lubrication of the main machine elements and mechanical systems.

• 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);

• Basic methods of technical diagnostics (diagnostics based on vibration monitoring, diagnosis based on the monitoring of thermal conditions and diagnostics through wear products in the lubrication oil).

• 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"; 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 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.

• Project task: A survey of potential types of failures; analyze of the probability, causes and consequences of real and potentional failures of the components or systems; using some of the failure analysis techniques (fault tree, Ishikawa diagram, Pareto analysis, FMEA etc.).

prerequisite

No special requirements.

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: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
auditory exercises: 0
laboratory exercises: 8
calculation tasks: 0
seminar works: 0
project design: 9
consultations: 13
discussion and workshop: 0
research: 0

knowledge checks: 15
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: 0
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: 0
project design: 10
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.

FLUID MECHANICS

Fluid mechanics B

Fluid mechanics B

ID: BSc-1289
responsible/holder professor: Stevanović D. Nevena
teaching professor/s: Lečić R. Milan, Milićev S. Snežana, Radenković R. Darko, Stevanović D. Nevena, Ćoćić S. Aleksandar
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: written
parent department: fluid mechanics

goals
The goal of the course is to teach the student the basics and applications in science of fluid flow. The essence in that sense is good understanding of fundamental equations of fluid mechanics. That good understanding of the equations makes the process of finding the solution in particular engineering problems which are dealing with fluid flow much easier.

Also another important goal of the subject is the teach the student the basics of experimental methods in fluid mechanics. This will be accomplished by the work in the laboratory.

learning outcomes
Learning the topics from the course student will get the knowledge about basic principles in fluid mechanics and capabilities of analytical thinking, then how to apply the knowledge in practical work, and also to make the connection between various subjects from mechanical engineering.

theoretical teaching
Fluids. Compressibility, viscosity, Newtonian and non-Newtonian fluids. The equation of state. Analysis of forces that acts on the fluid. State of stress, stress tensor. Fluid statics: Euler equation of statics and it's application. Pressure distribution in incompressible fluid. Hydrostatic forces on plane and curved surfaces. Pressure distribution in compressible fluid. Standard atmosphere. Fluid kinematics: Euler and Lagrange approach of description of fluid flow, streamlines, stream tubes, flow rate, mean values of physical quantities. Material derivative. Physical explanation of divergence of velocity. Continuity equation: differential and integral form. Motion of fluid particle: translation, rotation and deformation. Potential and rotational flow. Circulation and free vortex. Dynamics of inviscid flow: state of stress in inviscid flow, Euler equation. Bernoulli integral of Euler equation for steady and unsteady flow. Velocity measurements with Pitot and Prantdl probes. Basics of gas dynamics: energy equation, isentropic and isothermal flow, total and critical values of physical quantities, aerodynamic heating of the body, flow through convergent nozzle. Dynamics of viscous flow: state of stress in viscous flow, Navier-Stokes equation. Similarity theory, characteristic dimensionless similarity numbers. Dimensional analysis - wall shear stress in pipe flow and drag and lift force. Some exact solutions of Navier-Stokes equation: laminar flow between parallel plates and laminar flow in circular pipe. Basics of turbulent flow. Reynolds equations, basics of turbulence modeling. Prantdl mixing length theory. Turbulent flow in smooth pipes. Basics of boundary layer theory and Prandtl equations. Boundary layer separation. Dynamics of one-dimensional flow: Bernoulli equation for viscous fluid, continuity equation, momentum equation. Mean values and corrections coefficients. Friction effects in incompressible flow. Moody chart. Calculations of fluid flow in pipelines.

practical teaching
Physical properties of fluid. Calculations of stress state in fluid. Fluid statics. Absolute and relative pressure. Hydrostatic forces which acts on plane and curved surfaces. Pressure distribution in rigid-body motion of the fluid: constant acceleration and rotation in a cylindrical container. Pressure distribution in Earth's atmosphere.

Kinematics of the flow: determination of streamlines, volume and mass flow rates. Bernoulli equation. Some elementary problems from compressible fluid flows. Application of momentum and momentum of momentum equation. One dimensional flow in the pipes. Calculation of simple of complex pipeline systems. Basic examples in dimensional analysis. Laboratory work: measuring of velocity profile in pipe flow, determination of friction coefficient and pressure drop on local resistances.

prerequisite
Listener must be a student of the third year of undergraduate studies.

learning resources
Some chapters from books written by professors from the Chair, Handouts, and laboratory

equipment.

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
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: 15
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: 35
laboratory exercises: 5
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 55
requirements to take the exam (number of points): 20

references
Crnojević C., (2014): Mehanika fluida. Mašinski fakultet, Beograd.
Mehanika fluida B (handout) - Čantrak S., Lečić M, Ćoćić A.
Đorđević V., (2000): Dinamika jednodimenzijskih strujanja fluida, Mašinski fakultet, Beograd.
Crnojević C., (1998): Klasična i uljna hidraulika. Mašinski fakultet, Beograd.
Čantrak S., Benišek M., Pavlović M., Marjanović P., Crnojević C.: Mehanika fluida, teorija i praksa, Mašinski fakultet, Beograd, 2005.

GENERAL MACHINE DESIGN

- Machine elements 1
- Machine elements 2
- Mechanical Engineering Praxis

Machine elements 1

ID: BSc-1390
responsible/holder professor: Mitrović M. Radivoje
teaching professor/s: Kolarević M. Nenad, Lazović-Kapor M. Tatjana, Marinković B. Aleksandar, Mitrović M. Radivoje, Mišković Z. Žarko, Stamenić V. Zoran
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: written
parent department: general machine design

goals
Introduce the students in solving of practical tasks in mechanical engineering.

Teach students to understand components of mechanical systems, their functions, applications and variants of design solutions. Mastering the methods for calculation of operational safety,calculation of service life, and carrying capacity and also mastering the basics principles for machine elements design. Introduce the students to apply standards and other regulations in calculations and design of machine elements.

learning outcomes
After successful completion of this course, students should be able to:

• Recognize machine elements.

• Use of tolerance of dimensions, shape and position, and surface roughness.

• Perform basic calculations of strength of mechanical parts.

• Calculate and design shafts and axles.

• Select types of rolling and sliding bearings, calculate load capacity and design of installation.

• Design bolted joints and threaded load transmitters.

theoretical teaching
Machine elements: definition and classification. Linear size dimensions tolerance. Machine parts form, orientation, location and run out tolerances. Surface roughness tolerance. Stress concentration and critical (ultimate) stresses of machine parts. Types of machine part failures, fatigue and dynamic strength (endurance limit). Safety factor, design available stress, caring capacity of machine part. Failure of machine part surfaces, service stress and critical stress in machine part surface layer. Shafts, axles and pins: function, design forms, application. Shaft and axle loads, stresses, dynamic strength (endurance limits) and safety factor. Shaft stiffness. Shaft and hub connections: friction connections, key connections, spline connections. Rolling bearings (the function and application): types and characteristics of standard roller bearings. Bearing load - the equivalent load. Failures and service life

roller bearings. The selection and building in of roller bearings. Plain bearings: the function, characteristics, classification. Caring capacity of plane bearings without and with hydrodynamic lubrication. Heating, cooling and lubrication of sliding bearings. Design solutions, materials and shapes sliding bearing parts. Sealing of bearings. Thread and bolted threaded connections: the function, characteristics, classification. Screw bolted joints: longitudinally and transversely loaded (characteristics, classification, loading, clamping, strain, safety factors). Power screw assemblies.

practical teaching
Selection of linear size dimension tolerance. Analysis of clearance, interference and uncertain fits. Determination and calculation of stress concentration factors. Determination of machine parts dynamic strength (endurance). Calculation of safety factors of machine part. Load scheme of the shaft

identification. Loads and stresses of the shaft calculation. Determining of shaft dimensions and safety factor. Calculation of the shaft and hub connections. Determine of rolling bearing caring capacity and service life. The selection and building in of rolling bearings. Calculation of bolted thread joints, the choice of join type and calculation, calculation and design of screw power assemblies. Processing of project task, instructions for processing, monitoring and discussion with the students.

prerequisite
Defined by students curricula.

learning resources
Books>

- M Ristivojević., R Mitrovic., B Rosić: Machine elements 1, Faculty of Mechanical Engineering,Belgrade 2019

- M. Ognjanović.: Machine elements, Faculty of Mechanical Engineering, Belgrade 2008, 2011,2013, 2014;

- S Veriga.: Machine elements (volumes I and II) , Faculty of Mechanical Engineering,Belgrade

- Plavsic N., M Ristivojević., R Mitrovic., B Rosić., Jankovic M., P Obradovic.: Machine elements - a manual for the exercises - Faculty of Mechanical Engineering Belgrade 2006.;

- Plavsic N., M Ristivojević., R Mitrovic., B Rosić., Jankovic M., P Obradovic.: Machine elements - collection of solved test tasks - Faculty of Mechanical Engineering Belgrade 2000.

Handouts available on the web site or reproduced on paper:

- Lectures, questions and tasks for colloquiums

- Guidelines for project tasks

Video presentation:

- Simulation of mechanical elements operation,

- Video presentation machine parts production and measurement

- Display of design solutions

laboratory:

- Show of machine elements, parts and components,

- Demonstration of machine elements testing

- Simulation of machine parts operation and production.

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
auditory exercises: 6
laboratory exercises: 4
calculation tasks: 10
seminar works: 0
project design: 6
consultations: 4
discussion and workshop: 0
research: 0

knowledge checks: 15
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: 2
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: 0
calculation tasks: 25
seminar works: 0
project design: 10
final exam: 30
requirements to take the exam (number of points): 25

references
M Ristivojević., R Mitrovic., B Rosić: Machine elements 1, Faculty of Mechanical Engineering,Belgrade 2019
Ognjanovic, M.: Machine elements, - Faculty of Mechanical Engineering, 4. Edition, Belgrade 2014.
Матек W., Muhs D, Wittel H., Becker M: Roloff/Matek Machinenelemente, - Friedr. Vieweg & Son Verlag, Braunschweig
Decker : Machinenelemente - Cartl Hanser Verlag, Munchen.
Shigley J.: Mechanical Engineering Design, - McGrow Hill

Machine elements 2

ID: BSc-1391
responsible/holder professor: Mitrović M. Radivoje
teaching professor/s: Kolarević M. Nenad, Lazović-Kapor M. Tatjana, Marinković B. Aleksandar, Mitrović M. Radivoje, Mišković Z. Žarko, Stamenić V. Zoran
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: written
parent department: general machine design

goals
Introduce the students in solving of practical tasks in mechanical engineering.

Teach students to understand components of mechanical systems, their functions, applications and variants of design solutions. Mastering the methods for calculation of operational safety, calculation of service life, and carrying capacity and also mastering the basics principles for machine elements design. Introduce the students to apply standards and other regulations in calculations and design of machine elements.

learning outcomes
After successful completion of this course, students should be able to:

• Identify and monitor the current (transformation) of mechanical power in transmitters.

• Select the design parameters and conceptual design of the friction power transmitters.

• Determine the dimensions, select geometric parameters and design gears in the gear

transmitters.

• Calculate gear load capacity and operating safety (spur, helical, bevel and worm gears).

• Calculate load capacity and lifetime of belt and chain transmission pairs.

• Select and design of couplings (rigid, flexible, knuckle, toothed, friction).

theoretical teaching
Principles of mechanical power transformation, the basic equations of the transformation of mechanical power, transmission ratio and power transmission efficiency. Friction transmission units, the basic principles, performance, slip and wear in the contacts, materials of machine parts. Cylindrical gears (spur and helical), the basic principles of the teeth mashing, the geometry and kinematics of meshed gears. Strength and load capacity of cylindrical gears. Bevel and worm gears. Belt transmission pairs, load, stresses, service life. Chain transmission pairs. Couplings: rigid, flexible, knuckle, toothed, friction.

practical teaching
Determination of transmission ratios, torque, speed of rotation and power flows in gear structure, (power cabling in transmission unit). Calculation of gear teeth dimensions, gear dimensions, center distance, contact ratio etc. Strength (load capacity) of gears (spur, helical, bevel, worm). Calculation of belt transmission pairs geometry, loads, stresses, service life. Calculation of coupling load capacity. Display functions and design solutions, tests of strength and load capacity in the laboratory. Monitoring and instructing students to process project tasks.

prerequisite
Defined by students curricula.

learning resources

- Ristivojević M., Stamenić Z., Mitrović R.:Machine elements, Faculty of Mechanical Engineering, Belgrade 2021.

- M. Ognjanović.: Machine elements, Faculty of Mechanical Engineering, Belgrade 2008, 2011,2013, 2014;

- S Veriga.: Machine elements (volumes I and II) , Faculty of Mechanical Engineering, Belgrade

- Plavsic N., M Ristivojević., R Mitrovic., B Rosić., Jankovic M., P Obradovic.: Machine elements - a manual for the exercises - Faculty of Mechanical Engineering Belgrade 2006.;

- Plavsic N., M Ristivojević., R Mitrovic., B Rosić., Jankovic M., P Obradovic.: Machine elements - collection of solved test tasks - Faculty of Mechanical Engineering Belgrade 2000.

Hendauti available on the web site or reproduced on paper:

- Lectures, questions and tasks for colloquiums

- Guidelines for project tasks

Video presentation:

- Simulation of mechanical elements operation,

- Video presentation machine parts production and measurement

- Display of design solutions

laboratory:

- Show of machine elements, parts and components,

- Demonstration of machine elements testing

- Simulation of machine parts operating and production.

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
auditory exercises: 6
laboratory exercises: 4
calculation tasks: 10
seminar works: 0
project design: 6
consultations: 4
discussion and workshop: 0
research: 0

knowledge checks: 15
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: 2
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: 0
calculation tasks: 25
seminar works: 0
project design: 10
final exam: 30
requirements to take the exam (number of points): 35

references

Ristivojević M., Stamenić Z., Mitrović R.:Machine elements, Faculty of Mechanical Engineering, Belgrade 2021.
Ognjanovic, M.: Machine elements 2, - Faculty of Mechanical Engineering, 4. Edition, Belgrade 2006.-2014.
Decker : Machinenelemente - Cartl Hanser Verlag, Munchen
Shigley J.: Mechanical Engineering Design, - McGrow Hill
Матек W., Muhs D, Wittel H., Becker M: Roloff/Matek Machinenelemente, - Friedr. Vieweg & Son Verlag, Braunschweig

Mechanical Engineering Praxis

ID: BSc-0879
responsible/holder professor: Miloš V. Marko
teaching professor/s: Miloš V. Marko
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 5
final exam: written
parent department: general machine design

goals
Introduction of the students about all mechanical fields which are the subject of studying in Mechanical faculty from the point o view of practical work in each particular field: Control Engineering, Biomedical engineering, Naval architecture, Aerospace engineering, Design in mechanical engineering, Railway mechanical engineering, Welding and welded structures, Engineering of biotechnical systems, Industrial engineering, Information technologies, Motor vehicles, Internal combustion engines, Food industry engineering, Production engineering, Process engineering and environment protection, Weapon systems, Thermal power engineering, Material handling, constructions and logistics, Thermal science engineering, Hydropower engineering, Computational Engineering, Mechanics.

learning outcomes
The students will be introduced about practical work in all fields which are the subject of studying in Mechanical faculty.

theoretical teaching
Presentation of the any particular field - study module at Mechanical faculty.

practical teaching
Introduction to the resource of module's at the faculty for practical training.

prerequisite
None

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, laboratories, handouts.

number of hours: 75

active teaching (theoretical): 33
lectures: 33
elaboration and examples (revision): 0

active teaching (practical): 38
auditory exercises: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 38
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks: 4
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: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 45
project design: 0
final exam: 45
requirements to take the exam (number of points): 55

references
professor's handouts in electronic form (Moodle)

HYDROPOWER ENGINEERING

Fundamentals of turbomachinery

Fundamentals of turbomachinery

ID: BSc-0999
responsible/holder professor: Božić O. Ivan
teaching professor/s: Božić O. Ivan
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: oral
parent department: hydropower engineering

goals
Achievement of basic academic competence in the field of turbomachinery. Obtaining fundamental theoretical and practical knowledge about the principles of energy transfer process in turbomachinery. Mastering the knowledge of the essential components, proprieties and particularities of various types of turbomachinery. Development of the ability to apply turbomachinery in various energy systems and to calculate their main parameters by the acquired basic knowledge use.

learning outcomes
On successful completion of this course the students will be able to:

- recognize different types of turbomachinery and describe the principles of their operation in various power plants and energy systems,

- explain fundamental fluid flow and thermodynamic processes in turbomachinery,

- describe and differentiate the essential components of various turbomachinery (hydraulic turbines, pumps, fans and turbocompressors) from the point of their functioning and roles in the energy transfer process,

- define and calculate main specific geometry and energy parameters of turbomachinery,

- develop and implement the acquired knowledge in order to efficiently continue further improvement in the specialized courses for each particular type of turbomachinery.

theoretical teaching
Definition and classification of turbomachinery. Principles of turbomachinery operation. Theoretical basis of fluid mechanics and thermodynamics within energy transfer process in turbines, pumps, compressors and fans. Energy balance. Main parameters – discharge, specific work (head, isentropic, polytropic, real work), pressure ratio, torque, powers and efficiencies. Euler equation for turbomachinery. Description of essential components of radial-flow, mixed-flow and axial-flow turbomachinery. Absolute and relative fluid flow in impeller/runner. Velocity triangles. Similarity laws and dimensional analysis applied at turbomachinery operating with compressible and incompressible flows. Definition and application of dimensionless turbomachinery parameters – specific performance factors. Cavitation in turbomachinery (net positive suction head, cavitation coefficient and determination of the suction height). Operation characteristics of hydraulic and thermal turbomachinery. Overview of practical implementation and application of turbomachinery in plants and systems in various fields of engineering (hydropower, thermal power, thermal science, process, aerospace, railway mechanical, motor vehicle, naval). Overview of contemporary trends in development of turbomachinery.

practical teaching
Auditory exercises and calculation examples: Fundamentals of turbomachinery operation. Historical development, classification, properties and application of turbomachinery. Energy balance. Calculation of basic and main parameters of turbines, pumps, fans and compressors - specific work (isentropic, polytropic, real, head), discharge, torque, powers, efficiencies, hydraulic and mechanical power losses.

Application of Euler equation for the turbomachinery. Determination of velocity triangles, relation between specific works of turbomachinery unit and impeller/runner, the degree of reaction and main construction dimensions. Determination and application of unit and specific turbine dimensionless parameters in practice. Calculation of suction height.

Explanatory exercises in the laboratory for hydraulic machinery and energy systems: presentation of different types of turbomachinery constructions, essential components and their functions. Installations for testing turbines, pumps, fans and compressors.

Presentation of numerical experiment – the fluid flow simulation in turbomachinery using the contemporary CFD techniques.

Visiting the electric power systems, waterworks and process industry with the aim of demonstrating the practical operation of turbomachinery in the installations and plants.

prerequisite

-

learning resources

Books listed in the literature and more. Auditory exercises handouts.

Laboratory hydraulic machines and energy systems - devices, installations for testing turbines, pumps, fans, measuring equipment and exhibits

Faculty Computer Classroom

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
auditory exercises: 10
laboratory exercises: 5
calculation tasks: 10
seminar works: 0
project design: 0
consultations: 3
discussion and workshop: 2
research: 0

knowledge checks: 15
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: 5
test/colloquium: 40
laboratory exercises: 5
calculation tasks: 10

seminar works: 0
project design: 0
final exam: 40
requirements to take the exam (number of points): 30

references

N. M. Obradović: Osnove turbomašina, Građevinska knjiga, Beograd, 1973
Krsmanović Lj., Gajić A., Turbomašine - teorijske osnove, Mašinski fakultet, Beograd 2005.
Milun J. Babić, Svetislav Stojković: Turbomašine - teorija i matematičko modeliranje, Prosveta, Beograd, 1997.
Milun J. Babić: Zbirka rešenih zadataka iz turbomašina, Naučna knjiga, Beograd, 1990.
Gajić A., Pejović S.: Turbomašine - Ilustrativni i ispitni zadaci, Mašinski fakultet, Beograd, 1993.

INDUSTRIAL ENGINEERING

- Engineering Management and Economy
- English 1
- English 2
- Industrial ergonomics
- Maintenance management
- Production and Operations Management 1
- Production process optimization

Engineering Management and Economy

ID: BSc-1368
responsible/holder professor: Dondur J. Nikola
teaching professor/s: Veljković A. Zorica, Dondur J. Nikola, Milanović D. Dragan, Misita Ž. Mirjana, Spasojević-Brkić K. Vesna
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 4
final exam: written
parent department: industrial engineering

goals
The aim of this course is to acquire basic competencies and academic skills in the field of engineering management and economics with the development of critical thinking and ability for teamwork through: 1) acquiring basic knowledge about the importance of engineering management and economics; 2) understanding the success factors of the industrial system; 3) introduction to basic engineering-managerial and economic principles, functions, methods and techniques; 4) mastering modern approaches in management and economics, and 5) understanding the importance of ethics in the engineering profession.

learning outcomes
By mastering the subject of Engineering Management and Economics, students will be able to:

- understand and apply the basic principles, methods and functions of engineering management (planning, organizing, leading and controlling) in a way to work as a team and create conditions for permanent growth of productivity and efficiency, as a basis for improving the quality of industrial systems,

- to understand and apply economic principles to all areas of work in the company where relevant problems arise and to harmonize technical processes with economic requirements and

- understand and apply the principles of engineering ethics.

theoretical teaching
Engineering management and economics in modern business. Principles, functions, methods and techniques of engineering management. Planning: Basics of planning, planning process, decision making. Organizing: models of organizing and designing organizational structure. Leadership (management): business communication and management, the importance of motivation, teams and teamwork, conflicts in the organization, leadership as a determinant of engineering management, leadership theories. Control: Basic control functions, types, styles, control process, management standards / systems and business performance. Socioeconomic aspects of entrepreneurship and engineering management. Organizational culture. Innovation and resistance. Intellectual property. Professional ethics, social responsibility and morality. Principles of engineering ethics and solving ethical issues. Fundamentals of financial management and organization management. Micro and macro economics. Production and production factors. Production function, Production costs. Market, supply and demand. Prices and income. The system of economic relations with foreign countries. The concept of "sustainable economic development". Technological change, transition and globalization.

practical teaching
Exercises consist of auditory exercises, discussions and workshops that further develop selected topics that are relevant from both a theoretical and practical point of view, practical examples from the field of management and economics, and analysis and solving case studies and tasks. be used for preparatory consultations for the preparation and defense of seminar papers.

prerequisite
-

learning resources
Handouts and Moodle (http://147.91.26.15/moodle/).

number of hours: 45

active teaching (theoretical): 18
lectures: 12
elaboration and examples (revision): 6

active teaching (practical): 18
auditory exercises: 9
laboratory exercises: 0
calculation tasks: 5
seminar works: 4
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks: 9
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: 20
test/colloquium: 40
laboratory exercises: 0
calculation tasks: 5
seminar works: 5
project design: 0
final exam: 30
requirements to take the exam (number of points): 50

references
Pokrajac S., Dondur N., Introduction to Economics, Faculty of Mechanical Engineering, Belgrade, 2019
Spasojević Brkić V., Milanović D., et al., Quality Management System and Business Performance, MNTRS - Faculty of Mechanical Engineering, Belgrade, 2012.
Chang, C.M., Engineering Management: Meeting the Global Challenges, CRC Press, Boca Raton, 2016.
Stephen Robins, Timothy Judge, Organisational Behavior, Prentice Hall, 2013.
Brock B.E., and Herkert J. R., Engineering ethics. In Cambridge handbook of engineering education research, pp. 673-692. Cambridge University Press, 2015.

English 1

ID: BSc-0506
responsible/holder professor: Vesić-Pavlović S. Tijana
teaching professor/s: Vesić-Pavlović S. Tijana
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 2
final exam: written
parent department: industrial engineering

goals
Acquisition of vocational lexis related to fundamental concepts in sciences (measures, physical quantities). Adopting terminology related to branches of mechanical engineering.

Training students to use vocational literature in different fields of engineering. Developing reading and writing skills in engineering English.

learning outcomes
Upon the completion of this course, students will be able to:

- use vocabulary and text structures appropriate for engineering English,

- prepare and deliver a presentation in English related to mechanical engineering,

- write a CV and motivation letter in English.

theoretical teaching
Terminology of the fields of mechanical engineering, mathematics, physics and energy. Structure of a job advertisement in English, CV and motivation letter.

Descriptive grammar of English: nouns, pronouns, verbs, tenses, sentence structure, conditionals. Making PowerPoint presentations in English related to mechanical engineering.

practical teaching
Lexical and grammatical exercises (multiple-choice questions, gap-fill activities, answering questions, translation). Individual and group work. Oral presentations.

prerequisite
Defined by the curriculum of the study programme/module.

learning resources
1. Vesić Pavlović, T. (2018). NUTS AND BOLTS: English for Mechanical Engineering Students. Beograd: Mašinski fakultet.

2. Thomson,A. J. & A.V. Martinet (1986). A Practical English Grammar. Oxford: Oxford University Press.

number of hours: 30

active teaching (theoretical): 12
lectures: 8
elaboration and examples (revision): 4

active teaching (practical): 12
auditory exercises: 10
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 2
consultations: 0

discussion and workshop: 0
research: 0

knowledge checks: 6
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: 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: 0
project design: 25
final exam: 65
requirements to take the exam (number of points): 20

references

English 2

ID: BSc-0489
responsible/holder professor: Vesić-Pavlović S. Tijana
teaching professor/s: Vesić-Pavlović S. Tijana
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 2
final exam: written
parent department: industrial engineering

goals
Acquisition of vocational lexis related to different engineering areas (engineering materials, machine members, internal combustion engines, aeronautical engineering, artificial intelligence). Developing oral and translation skills in engineering English.

learning outcomes
Upon the completion of this course, students will be able to:

- use mechanical engineering vocabulary,

- analyze and adequately translate engineering texts into Serbian,

- use passive forms in oral and written language.

theoretical teaching
Terminology of the fields of engineering materials, machine members, pumps, turbines and internal combustion engines, aeronautical engineering, artificial intelligence. Interpreting charts. Descriptive grammar of English: verbs, active and passive voice, relative clauses.

practical teaching
Lexical and grammatical exercises (multiple choice questions, gap-fill activities, answering questions, translation). Individual and group work. Analyzing texts in English, making summaries and translation.

prerequisite
Defined by the curriculum of the study programme/module.

learning resources
1. Vesić Pavlović, T. (2018). NUTS AND BOLTS: English for Mechanical Engineering Students. Beograd: Mašinski fakultet.

2. Thomson,A. J. & A.V. Martinet (1986). A Practical English Grammar. Oxford: Oxford University Press.

number of hours: 30

active teaching (theoretical): 12
lectures: 8
elaboration and examples (revision): 4

active teaching (practical): 12
auditory exercises: 10
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 2
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks: 6
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: 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: 0
project design: 25
final exam: 65
requirements to take the exam (number of points): 20

references

Industrial ergonomics

ID: BSc-0075
responsible/holder professor: Žunjić G. Aleksandar
teaching professor/s: Žunjić G. Aleksandar
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
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 industrial ergonomics, which can be used for designing, evaluation 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 engineering problems.

learning outcomes
Upon successful completion of this course, students should be able to:

• Identify common factors that are important for the successful operation of the man - machine - environment system

• Determine the reliability of a man and a system from the ergonomic aspect

• Identify the factors that have the impact on the visibility, legibility and readability of alphanumeric information

• Apply the acquired knowledge on proper selection and coding of controls

• Recognize the importance of applying the anthropometry to design products and jobs and apply basic anthropometric criteria in the design of systems

• Apply the basic principles of biomechanics to the design and execution of working tasks

• Calculation and assess physical fatigue of man while performing different tasks

• Apply different modalities of presentation of information depending on the specific situation, in accordance with the theory of signal detection, as well as the theory relating to the receipt and processing of information

• Carry out an assessment of mental workload

• Perform an assessment of noise of variable levels, based on the criteria and procedures for assessing the harmful effects of time-varying noise

• Estimate adverse effects of vibration on the human body

• Estimate effects of different levels of acceleration on the human body

• Apply ergonomic recommendations for the design of computer interfaces

• Apply in practice different methods for assessing the usability of a system

• Calculate and assess the usability of websites

theoretical teaching
Introduction to industrial ergonomics. Defining of a system and the man - machine system. System reliability and reliability of a man. Basic visual function and vision. Legibility, visibility and readability of alphanumeric information. Controls. Fundamentals of the engineering anthropometry. Biomechanics of movement, types and ranges of motion. Energy of work and fatigue. Receiving and processing of

information. Nature and effects of noise. Vibrations, impact on the human body and work ability. Movement, acceleration and deceleration, effects on the body. Basics of computer interface. Examples from practice - ergonomics of packaging. Ergonomic research methods - usability evaluation.

practical teaching
Laboratory exercise: Evaluation of changable noise - here are presented the criteria and procedure for assessing of the harmful effects of noise and performs an estimation of harmful effects of noise in the selected workplace. Laboratory exercise: Assessment of physical work effort - here are presented the criteria and procedure for assessing physical effort during the work, and the work that is performed in laboratory conditions is an object of estimation. Making of project - Assessment of usability of software / web presentation. 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.

prerequisite
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. Fonometer - available in the lab. 417. CAD working station, available in the lab. 455. Software package Ergoeaser, available in the lab. 455.

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
auditory exercises: 0
laboratory exercises: 10
calculation tasks: 0
seminar works: 8
project design: 6
consultations: 5
discussion and workshop: 1
research: 0

knowledge checks: 15
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: 4
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: 20
calculation tasks: 0

seminar works: 20
project design: 10
final exam: 40
requirements to take the exam (number of points): 40

references

Žunjić A. and Ćulić M., 2007, Practicum for laboratory exercises in industrial ergonomics, Faculty of Mechanical engineering, Belgrade.
Klarin M. and Žunjić A., 2007, Industrial ergonomics, textbook, Faculty of Mechanical engineering, Belgrade.
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.

Maintenance management

ID: BSc-0414
responsible/holder professor: Bugarić S. Uglješa
teaching professor/s: Bugarić S. Uglješa
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: written
parent department: industrial engineering

goals
Perception of position and cost of maintenance within life cycle of technical systems. Acquaint ion with parameters which affect design of maintenance organization. Practical determination and analyze of technical system reliability. Acquaint ion with standard malfunctions, methods for condition monitoring as well as with equipment for condition monitoring. Overwhelm with methods for determination of replacement and reparation strategies, maintenance costs and inventory optimization. Acquaint ion with possibilities of maintenance system optimization and application of computer systems – business solutions.

learning outcomes
Curriculum overcome enables overwhelm with necessary knowledge and skills (models, optimization procedures, monitoring and measure equipment, basics of computer systems – business solutions) for implementation in maintenance organizations of complex technical and complex systems.

theoretical teaching
Significance, organization parameters and structure of maintenance system. Reliability of technical systems – reliability of element until first failure. Empirical determination of element reliability and reliability of complex systems. Recovery process and strategies of replacements and reparations. Replacement models. Categorisation and planning of maintenance works. Standard malfunctions and methods for machine condition monitoring. Methodology for weak spots seeking. Maintenance costs. Spare parts. Inventory optimization. Inventory management – deterministic and stochastic models. Determination of indicators of maintenance system work. Queuing theory – finite source (calling population) systems. Occupational safety and health at work. Inspection and examination of work equipment. Examining the conditions of working environment. Enterprise Asset management. Introduction to basics and navigation in SAP solutions based on SAP ERP.

practical teaching
Audit lessons (Maintenance position in company organisation structure. Reliability of element until first failure calculation. Reliability of complex systems – examples of serial, parallel, passive parallel, partially parallel relations between elements. Strategies and models of replacements – examples with and without discount factor (rate) and with compete and partial write-off. Repair (maintenance) complexity. Weak spots. Inventory management – deterministic and stochastic models. Queuing theory – finite source (calling population) systems – models with and without help between servicing channels.). Occupational safety and health at work - practical examples.

Seminar work (Analysis of gathered data about malfunction on real system, determination of malfunction intensity, determination of probability density function of time until malfunction, using chi-square test.).

Laboratory work (Acquaint ion with standard and advanced equipment for system condition monitoring - SKF, as well as with possibilities of implementation of maintenance module in company computer systems – business solutions - using exercises & Case study - SAP module EAM (Enterprise Asset Management)).

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. Bugaric, U., Petrovic, D.: Softvare for verification of sample belongings to theoretical distribution using chi-square test, Faculty of Mechanical engineering Belgrade, Belgrade, 1996-2010.

5. Klarin, M., Ivanovic, G., Stanojevic, P., Raicevic, P.: Principles of therotechnological actions, Faculty of Mechanical engineering Belgrade, Belgrade, 1994.

6. Software: QtsPlus 3.0 (Queuing theory software Plus).

7. Practical instruction in industrial environment (SKF, SAP).

8. Mobile devices for measurement of temperature and vibrations.

9. Personal computers.

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
auditory exercises: 15
laboratory exercises: 10
calculation tasks: 0
seminar works: 5
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks: 15
check and assessment of calculation tasks: 0
check and assessment of lab reports: 3
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: 10
test/colloquium: 40
laboratory exercises: 10
calculation tasks: 0
seminar works: 10
project design: 0
final exam: 30

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

references

Baldin, A., Furlanetto, L., Roversi, A., Turco, F.: Handbook for maintenance of industrial plants, Održavanje Mašina i Opreme – OMO, Belgrade, 1979.
Ivkovic, S.: Failures of mining machine elements, Rudarsko-geološki fakultet Beograd, Belgrade, 1997.
Vukadinovic, S., Teodorovic, D.: Elements of reliability theory and recovery theory of technical systems (second edition), Privredni pregled, Belgrade, 1979.
Vujanovic, N.: Reliability theory of technical systems (second edition), Vojnoizdavački i novinski centar, Belgrade, 1990.
Hillier, F. S., Lieberman, G. J.: Introduction to operations research (seventh edition), McGraw-Hill, New York, 2000.

Production and Operations Management 1

ID: BSc-0602
responsible/holder professor: Spasojević-Brkić K. Vesna
teaching professor/s: Spasojević-Brkić K. Vesna
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: written
parent department: industrial engineering

goals
The aim of this course is to acquire knowledge and practical skills in the field of theory and practice of the production management. Mechanical engineers after taking this course are trained to perform diagnostics and to apply methods for raising the general level of enterprise organization and rationalization of operations and production. Methods and techniques for production and operations management are useful in everyday tasks of mechanical engineers irrespective of the job specialization.

learning outcomes
Upon successful completion of this course, student acquires the following competencies: 1. Diagnosing the state of the organization of the company, 2. Organizational structure design , 3. Tools for rationalization of production and operations processes application in the company 4. Analysis of the success rate of an enterprise and accordingly are able to diagnose the level of organization and 5. explain the connection between the above mentioned competencies to make decisions, and, accordingly upon the course completion is able to design organizational structure and make rationalization of production processes according to calculated success rates. After completion of the course students also demonstrate an awareness and an appreciation of the importance of the operations and production management to the sustainability of an enterprise and are trained to solve real problems using scientific methods and techniques of production and operations management.

theoretical teaching
Basic concepts of production and operations management. Modern tendencies in the production and operations management. Principles of structuring of the production system. Contingency factors influence on design of the organization. Types of organizational structures. Products chart. Material Requirements Planning. Inventory management. The function of planning and analysis. Production cycle time. Production planning and scheduling. Techniques of network planning - CPM/PERT. The calculation of production capacity. Linear programming. Types of production. Technical and technological documentation. Time structure of the production cycle. Inventory control. Maintenance management. Quality management in manufacturing companies. Indicators of financial performance. Designing organizational structure.

practical teaching
Design of Macro-organizational structure of manufacturing enterprises with particular emphasis on the organizational structure of the production function micro level. Solution of practical problems in the areas of linear programming, network planning - CPM, inventory management and capacities calculations and production cycle time measurement. The corporate performance measures calculation.

prerequisite
Students need to enroll 5th semester.

learning resources
1. Bulat V., Organization of production, Faculty of Mechanical Engineering, Belgrade, 1999.(in Serbian)

2.Jovanovic T., Milanovic D. D., V Spasojevic., Modern organization and management, Faculty of Mechanical Engineering, Belgrade, 1996. (in Serbian)

3.M., Industrial Engineering, Volume 1, The organization and planning of production processes, Faculty of Mechanical Engineering, Belgrade, 1996. (in Serbian)

4.Tersine J.R., Production/Operations Management: Concepts, Structure and Analysis, Appleton & Lange, New York, 2005.

5. Rodrigues J., Cardoso P., Monteiro J., Figueiredo M. (2016). Handbook of Research on Human-Computer Interfaces, Developments, and Applications. IGI Global.

6. Handout

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
auditory exercises: 1
laboratory exercises: 0
calculation tasks: 6
seminar works: 0
project design: 18
consultations: 5
discussion and workshop: 0
research: 0

knowledge checks: 15
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: 4
colloquium, with assessment: 2
test, with assessment: 1
final exam: 5

assessment of knowledge (maximum number of points - 100)
feedback during course study: 5
test/colloquium: 30
laboratory exercises: 0
calculation tasks: 15
seminar works: 0
project design: 20
final exam: 30
requirements to take the exam (number of points): 30

references

Bulat V., Organization of production, Faculty of Mechanical Engineering, Belgrade, 1999.(in Serbian)
Jovanovic T., Milanovic D. D., V Spasojevic., Modern organization and management, Faculty of Mechanical Engineering, Belgrade, 1996. .(in Serbian)
Klarin M., Industrial Engineering, Volume 1, The organization and planning of production processes, Faculty of Mechanical Engineering, Belgrade, 1996. (in Serbian)
Tersine J.R., Production/Operations Management: Concepts, Structure and Analysis, Appleton & Lange, New York, 2005.
Rodrigues J., Cardoso P., Monteiro J., Figueiredo M. (2016). Handbook of Research on Human-Computer Interfaces, Developments, and Applications. IGI Global.

Production process optimization

ID: BSc-1170
responsible/holder professor: Misita Ž. Mirjana
teaching professor/s: Veljković A. Zorica, Misita Ž. Mirjana
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: written
parent department: industrial engineering

goals
The aim of this course is to familiarize students with the basic characteristics of production processes, with special emphasis on small production companies. The first goal is formation and planning of the production process for a product through theoretical preparation. Another objective of the course is theoretical and practical familiarization of students with the basic characteristics of enterprises functioning with respect to the all elements related to production processes. Familiarization of students with basic objective goals and real constrains which influence on production process flow.

learning outcomes
Upon successful completion of this course, students should be able to:

- Recognize and distinguish the characteristics of the production processes,

- Analyze the efficiency of production processes,

- Identify problems which may arise in the manufacturing process,

- Set objective goals,

- Identify real constrains on production process,

- Select and apply appropriate optimization production process methods,

- Select and propose appropriate solutions to improve production processes,

- Identify adequate information system for managing production processes,

- Evaluate implementation of the designed solution.

theoretical teaching
The theoretical part of this course: the first part introduces students to the organizational structures related to production processes, recursive process of forming a new product. Process of forming the material component, with single-level, hierarchical, technological and temporal formation of components, with a budget of progressive work. Duration of the production cycle. Manipulation, management and monitoring material flow through production processes and methods and characteristics of material storage, raw materials and products.

In the second part of this course the focus is placed on analysis of available production resources - machines, material and man-power. Identification of real constrains according ta available real constrains. Analysis of optimal criteria, mostly minimum costs, maximum profit, maximum capacity utilization of machine capacities, or other production resources. Analysis of methods for production process optimization. Analysis of information systems for integral production processes management (ERP).

practical teaching
Practical part of this subject includes team work in groups of three students. Students choose a product that will produce, define its characteristics, form a component of the material, technological and

operational component. The production of a specific series is formed on the basis of the limits set in the volume of production and factory capacity and available manpower.

In second part of this course is planed: analysis of real example of production process and calculation of utilization coefficient each of production resources. Design of real constraints and optimization criteria. Application of production process optimization methods for suggestion of optimal production volume.

prerequisite
Enrolled the fourth semester of undergraduate studies.

learning resources
Electronic form of highlights from lectures and exercises will be available to the students. There will also be shown the appropriate contemporary models and applications on computers.

number of hours: 75

active teaching (theoretical): 26
lectures: 26
elaboration and examples (revision): 0

active teaching (practical): 39
auditory exercises: 0
laboratory exercises: 39
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks: 10
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: 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: 5
final exam: 45
requirements to take the exam (number of points): 30

references
Bulat V., 1999, Organization of production, FME, Belgrade /In Serbian/
Salvendy G., 2001, Handbook of Industrial Engineering, John Wiley & Sons, Canada

INFORMATION TECHNOLOGIES

- Basic WEB projecting
- Database design
- Engineering communication
- Information integration of business functions
- Software engineering 1
- WEB projecting in mechanical engineering

Basic WEB projecting

ID: BSc-0432
responsible/holder professor: Mitrović B. Časlav
teaching professor/s: Bengin Č. Aleksandar, Vorotović S. Goran, Mitrović B. Časlav
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: project design
parent department: information technologies

goals
Course objective:

• To acquaint students with the importance and benefits of Web and Web programming.

• To make students adopt some of the methodologies of data preparation for Web

• To make students know the basic Web application to accept and display the data.

• The creation, introduction and use of the Web Site

• Determining the functionality of your own web site

learning outcomes
The acquired knowledge allows students:

• to prepare, make and display their own skills,

• to determine the functionality of the Web site,

• to prepare and implement Web applications,

• to prepare and implement a simple Web site,

• working in a team, prepare and implement any Web site.

theoretical teaching
WEB ARCHITECTURE (Internet–Web; specific Web application, basics of HTTP, WAP protocol) LANGUAGE HTML, XML.

BASICS OF JAVA Java abstract layer; (Java servlets and Java applets, network protocols)

PROGRAMMING ON THE USER (hierarchy, event and timing component management ; introduction to ASP)

USING database (JDBC, PHP, ASP, transaction models, distributed computing, CORBA, RMI, DCOM)

PREPARATION OF WEB DOCUMENTS (legal terms, the control input, testing, authoring tools according to W3C; criteria)

WEB DESIGN (planning, implementation, design of Web pages; typography, editorial style, graphics, graphic file formats, image maps, multimedia)

Intelligent agents. SAFETY (introduction, architecture, ways of implementation, application, security on the Web; Wessex protocols, identification and verification)

DESIGN PRESENTATION AVAILABLE TO INVALIDS (various disabilities, visual, auditory, motor and cognitive disabilities, limitations and instructions)

practical teaching
Analysis of Web sites on the Internet. Determining the optimal Web site. Definition of personal presentation. Making personal presentations and set up and run on a local server. Discussion on advantages and disadvantages of the used tools. Posting remarks on the network to other authors of presentation. Compiling all the presentations and making the home page. Selecting editor to write the code. Creating personal Web site. Formatting documents in HTML. Formation of the list.; Creating hyperlinks, addressing, use of images, forming tables (Table); frames or zone (frame); creating forms. Selecting the best tool for Web applications. Individual work tasks using HTML, XML, XHTML, JavaScript and Java. Preparation for the project of team working on Web site. Analysis of the goals, objectives and anticipating problems that may occur in the preparation of Web site. Defining the profile and requirements. Presentation plan. Model of presentation. Realization of experimental Web Site.

prerequisite
'defined by curriculum of study program / modules'

learning resources
To successfully master the subject, it is necessary the use of textbooks, manuals for the project, handouts, Internet resources. IT equipment (appropriate hardware and software) ICT, available in the laboratory 457)

number of hours: 75

active teaching (theoretical): 20
lectures: 20
elaboration and examples (revision): 0

active teaching (practical): 40
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: 15
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: 5
calculation tasks: 0
seminar works: 10
project design: 20
final exam: 30
requirements to take the exam (number of points): 35

references

Č.Mitrović, S. Radojevic: Fundamentals of Web design, textbook: ISBN 978-86-7083-596-2, 164 pages., Full color, graphics, A4 format, published by Faculty of Mechanical Engineering, Belgrade 2007

Database design

ID: BSc-1401
responsible/holder professor: Lazović M. Goran
teaching professor/s: Vorotović S. Goran, Lazović M. Goran, Mitrović B. Časlav
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: project design
parent department: information technologies

goals
The main goal of this course is to understand the basic concepts necessary for the design, implementation and use of a functional database.

learning outcomes
Students will be able to apply basic techniques of database design and implementation without anomalies. They will also acquire the skills for database manipulation that are necessary for both database administration and database application development.

theoretical teaching
Concepts and architecture of database management systems. Data model. Conceptual data model, entity relationship model. Logical data model, relational model. Relational algebra, SQL. Data anomalies, functional dependence. Armstrong's rules. Normal forms and decomposition. Physical model, secondary memory. I/O computation model. File organization. Index files, indexes. Parallel processing, transactions.

practical teaching
Real system database design and implementation development in a modern environment by using certain database management system.

prerequisite
No prerequisites for attending classes

learning resources
Computer lab

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
auditory exercises: 10
laboratory exercises: 20
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks: 15
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: 15

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: 40
final exam: 60
requirements to take the exam (number of points): 30

references

Gordana Pavlović-Lažetić, Uvod u relacione baze podataka
Ramakrishnan, Gehrke; Database Management Systems

Engineering communication

ID: BSc-0384
responsible/holder professor: Bengin Č. Aleksandar
teaching professor/s: Bengin Č. Aleksandar
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: project design
parent department: information technologies

goals

• Understanding the importance and gaining ground skills in the preparation and execution of communication with different customers (management, professional services, colleagues and clients).

• Introduction to the creation, presentation and use of engineering documentation. Computer processing of documentation

• Identifying the basic functional units in companies, and learning about mutual communication these entities.

• Understanding the basic documents that characterize the activities of companies. Preparation for the Computer processing of these documents.

learning outcomes

The acquired knowledge enables listener:

• to prepare, create and display their own skills.

• to prepare, make and present a report on the accomplished work.

• to prepare, perform and manage the presentation, discussion.

• to recognize the basic functional units of the company, and to notice interdependent.

• to recognize the basic documentation of the company, and

• to prepare the basic documentation for computer processing.

theoretical teaching

Communication (oral and written; parameters, the application of computers in communication).

Organizing communication (structure and content; defining, evaluating and managing information, organizing ideas and facts).

The speech (voice and body language, audience and management issues, and managing a set of discussion).

Engineering documentation (contracts, offers, CV, bills, invoices, technological documentation, reports).

The company as a generator of information (organizational units of small and medium enterprises; supplies; norms, accounting).

On some documents (inventories, stock lists, card material). Enterprises; supplies; norms, accounting).

A coding system (definition and enforcement, bar code, the parallel coding system, application in the supply).

BOM (modular, hierarchical, two-level, generic bill explosion, obtaining bill explosion).

Archive, send, protect documentation (copies, storage place, send the documentation; encryption). About presentation (collection, processing, selection of information, organization and planning of the presentation).

practical teaching
Practical exercises consist of learning about the creation of technical documentation and documents for communication. It is also used appropriate software. Development of two projects CV and presentation of a problem with topic on information technology are the essence of practical training.

prerequisite
Without prerequisites.

learning resources
number of hours: 75

active teaching (theoretical): 20
lectures: 20
elaboration and examples (revision): 0

active teaching (practical): 40
auditory exercises: 6
laboratory exercises: 16
calculation tasks: 0
seminar works: 5
project design: 10
consultations: 0
discussion and workshop: 3
research: 0

knowledge checks: 15
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: 15
calculation tasks: 0
seminar works: 15
project design: 20
final exam: 30
requirements to take the exam (number of points): 35

references

Information integration of business functions

ID: BSc-0614
responsible/holder professor: Mitrović B. Časlav
teaching professor/s: Vorotović S. Goran, Mitrović B. Časlav
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
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 a business system.

• The cybernetic definition of business processes and business domains.

Lesson 3

• Theory for designing integrated digital company / factory.

• CIMOS functional entities and the transfer of information across levels of business.

Lesson 4

• Modeling for enterprise integration and a digital description of the business.
• Modeling of educational and business environment is an integrated enterprise.

Lesson 5

• Engineering database / knowledge and standard interfaces.
• Design of technical systems, products and technologies.
• The documentation and electronic exchange of information.

Lesson 6

• Management of supply chain information integration with business partners.
• Optimal flow through the business sectors and facilities.
• Management and storage of materials throughout.

Lesson 7

• Information flow and integrated business tools.
• Flexible cell technology, systems and production facilities.
• Integrated maintenance and diagnostics.

Lesson 8

• An integrated system of quality assurance.
• Allocation of available resources.
• Multi-criterion decision-making.
• Procedures for quality.
• Quality standards.

Lesson

• Technology innovation in business.
• engineering and re-engineering of business processes and systems.
• Management costs.
• Information and communication infrastructure is an integrated enterprise.

10th Chapter

• The development and life cycle of the business system.
• Business performance intelligent digital business enterprises.
• The business profile and marketing companies / industries.
• 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
• unconditionally previously passed exams.

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: 75

active teaching (theoretical): 20
lectures: 20
elaboration and examples (revision): 0

active teaching (practical): 40
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: 15
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.

Software engineering 1

ID: BSc-0529
responsible/holder professor: Mitrović B. Časlav
teaching professor/s: Bengin Č. Aleksandar, Vorotović S. Goran, Mitrović B. Časlav
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: written+oral
parent department: information technologies

goals

• Acquisition of 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.

• The acquisition of skills which overcome the barriers to collaboration in teams to write and implement software.

learning outcomes

• to participate in the software team as a team member with special knowledge related to mechanical engineering,

• to notice problems in the design and determine the problematic processes that can influence and some numerical mark on the project,

• to prepare all the necessary data for modeling of certain parts of the software,

• to prepare vallide documentation for software,

• to participate in the implementation of the software with the contractor.

theoretical teaching

About software engineering, models and modeling (introduction, model theory, sketches of model ...; numerical parameters of model).

Costs, prices and use the software (price, role of engineers and engineering, hardware and software, software with errors, types of software bugs).

The organization of software projects (people, team development; individual roles; productivity and the impact on productivity, types of software projects, organization of software companies).

Modeling of software development and processes (Pert; relationship with the client; different types of modeling and software development, process definition, classification process, process management).

The documentation, software quality and metrics (goal; possibilities of electronic documents; standards for documentation, managing and documenting software defects and errors, audit software).

Software for software development (special tools for developing GUI application components; code generators, and some examples of the application).

Analysis, specification and drafting software (applications, data collection and processing, internal standards for the collection and processing of applications; importance of sketching and drafting software).

Coding, testing and integration of software (the programming language, coding, editors; way of testing software, software integration and software integration strategy, expected and unexpected problems in integration of software).

Configuring and reliability of software (software configuration; special features of the software).

Re-engineering and reuse of software (software evolution in all aspects of the project).

practical teaching
Practical classes:

It consists of laboratory exercises that accompany the objects, and continuous monitoring of the project through the creation of the final four seminar papers.

prerequisite
Preferred: Web design in mechanical engineering, database design as well as objects 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 and software appropriate) ICT, available in the laboratory 457).

number of hours: 75

active teaching (theoretical): 20
lectures: 20
elaboration and examples (revision): 0

active teaching (practical): 40
auditory exercises: 6
laboratory exercises: 20
calculation tasks: 0
seminar works: 3
project design: 8
consultations: 0
discussion and workshop: 3
research: 0

knowledge checks: 15
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: 3
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: 15
calculation tasks: 0
seminar works: 15
project design: 20
final exam: 30
requirements to take the exam (number of points): 35

references

WEB projecting in mechanical engineering

ID: BSc-0070
responsible/holder professor: Mitrović B. Časlav
teaching professor/s: Bengin Č. Aleksandar, Vorotović S. Goran, Mitrović B. Časlav
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: project design
parent department: information technologies

goals
Course objective

• Understand the importance of Web sites in Mechanical Engineering,

• The creation, introduction and use of Web projects,

• Determining the functionality of Web projects,

• Preparing your own Web projects,

• Understanding and preparing the necessary documentation for the implementation of Web projects in Mechanical Engineering

learning outcomes
The acquired knowledge allows the:

• prepare, make and display your own skills,

• determine the functionality of all the specifications on the Web,

• prepare, perform and manage the designing of Web presentations,

• determine the technology of designing Web sites,

• recognize the requirements of the local machinery industry for Web presentations,

• create a necessary documentation of Web project,

• implement and collect Web project.

theoretical teaching
EVOLUTION OF THE SITE (customize and manage information in real time, Web services protocols, distributed applications, (in) compatibility of older protocols)

DOMAIN (generic and territorial domain, and the choice of the name, subdomains)

Web Design (theme, technology and design web site, templates, navigation, HomePage, content and readability of Web page; redesigned Web)

WEB SITE DESIGN (Web competition, testing and checking the Web)

CREATING AND PROGRAMMING Web - A (HTML, XML, XHTML, XSLT, CSS, HTAs)

CREATING AND PROGRAMMING Web - B (Java Script, Java)

CREATING AND PROGRAMMING Web - C (SQL, Server Side Scripting, Web services)

Web elements (tools and readers, Free Hosting, HTTP compression, and client-server setup, HTTP messages and warnings)

DESIGNING WEB SERVICES (life cycle of Web, development, analysis, technology and tools)

Web Development Presentation (price, vision, technology, design, price list, installation, maintenance and promotion of the website)

practical teaching
Search for existing patterns of web presentation, specific to mechanical engineering.Joomla. Technology of Web design, web site creation layout pattern. Analysis whit defined rules of navigation, the navigation, rules for creating a Web page and the proper approach to the formation of introductions - Home Page. Problems with readability and refresh Website content. Comparing the quality of several available Web browser. Some limitations and advantages of Free Hosting. Analysis and resolution of simple communication problem. Responding to HTTP messages and warnings. Assessment for life cycle of WebSite and the strategy for maximum extension of the life cycle Web site. Understanding the tools to design and develop Web sites -applications with a short life expectancy. Assessment of cost efficient web site with a short life expectancy. Design, implementation and use of physical implementation of selected examples of Web sites.

prerequisite
Preferred: Basic Web design and engineering communication as well as objects 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 and software appropriate) ICT, available in the laboratory 457).

number of hours: 75

active teaching (theoretical): 20
lectures: 20
elaboration and examples (revision): 0

active teaching (practical): 40
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: 15
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: 20
laboratory exercises: 5
calculation tasks: 0
seminar works: 20

project design: 20
final exam: 30
requirements to take the exam (number of points): 35

references

MATERIAL HANDLING, CONSTRUCTIOS AND LOGISTICS

Elements of Construction and Mining Machines

Fundamentals of steel structures

Material Handlig Equipment

Elements of Construction and Mining Machines

ID: BSc-0044
responsible/holder professor: Bošnjak M. Srđan
teaching professor/s: Bošnjak M. Srđan, Gnjatović B. Nebojša
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
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 construction and mining machines and appliances. 2) mastering practical skills which are necessary for selection, design and calculation of construction and mining machines.

learning outcomes
After successfully completing this course the student should be proficient in:

- Calculating basic parameters of various types of excavators and loaders;
- Calculating basic geometrical parameters of excavator buckets (length, height, depth) of known volume;
- Properly choosing and calculating basic geometrical parameters of bucket teeth;
- Performing resistance-to-excavation, bucket filling and dug material prism movement calculations;
- Determining loads acting on excavator boom, bucket and bucket holder;
- Develop a conceptual design of a mini-excavator.

theoretical teaching
Short survey on the development of construction and mining machines. Technology of earthmoving work in construction industry and mining. Basic structural scheme of construction and mining machines. Types of working devices and equipment. Drive and transmission systems. Main design parameters. Interaction between cutting elements and soil. Excavators and loaders. Equipment for preparation, excavation transport and planning. Machines for soil stabilization. Machines and plants for aggregate production, production and installation of concrete and asphalt concrete.

practical teaching
Calculation of backhoe excavators, power shovels (front shovels), dragline excavators and loaders. Calculation of basic geometrical parameters of bucket (width, height, length) of known volume. Adoption and calculation of basic geometrical parameters of teeth (width, length, cutting angle, geometry of the cutting wedge, rear angle). Calculation of working loads caused by soil excavation. Load analysis of excavating device. Static stability. Calculation of loader. Conceptual design of mini excavator. Consultations.

prerequisite
Required previously passed courses: Engineering Graphics, Strength of Materials, Material Science, Machine Elements 1.

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, Elements of construction and mining machines, - Instructions for project realization, University of Belgrade, Faculty of Mechanical Engineering, Belgrade, 2008.,

4. Computers, Laboratory 516,

5. Software Mathlab, (Catia)

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
auditory exercises: 9
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 15
consultations: 5
discussion and workshop: 1
research: 0

knowledge checks: 15
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: 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
Momir M. Plavšić, Construction Machines, Scientific Book, Belgrade, 1990.

Fundamentals of steel structures

ID: BSc-0908
responsible/holder professor: Gašić M. Vlada
teaching professor/s: Gašić M. Vlada
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: written
parent department: material handling, constructios and logistics

goals
Basic goals of this course are: 1) introduction to logical principles in design and calculation of steel structures in mechanical engineering, 2) development of student creative skills in design of joints for characteristic structural systems throughout phases of idealization, parameterization and calculation.

learning outcomes
After the completion of the course, student is trained to:

- Set the suitable static model for different types of crane structures (like monorail and jib cranes) and analyze the effect of self-weight and payload
- Carry out basic stress proof of simple structures (beams, cantilever and frames)
- Calculate the welded joints of structures
- Calculate the bolted joints of structures
- Create the project of bolted connections for parts of I-beam girders
- Calculate the truss forces (for statically determined trusses) and perform the buckling analysis

theoretical teaching
Properties of steel structures. Types of loads and design methods for structures. Design criteria of structures, check for: stresses, deflections, structural stability, connections, geometric stability and buckling. Welded connections. Bolted connections. Beams and frames. Trusses. Basic calculation of plane structural components.

practical teaching
Stresses and deflections for simple beam and cantilever due to various loads with examples of simple cranes. Calculation of fillet weld and bevel weld connections. Design of joints at simple L frame. Calculation of bolted connections. End-plate moment connections. Calculation of splice connection of the I-beam. FEA design check of connections. Buckling resistance of members. Calculation of forces in the members of statically determinate trusses.

prerequisite
Necessary courses: Mathematics 1, Strength of materials, Engineering materials 1.

learning resources
Laboratory (room 516) with computers and software.

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
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: 15
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: 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: 10
calculation tasks: 20
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

Vlada Gašić: Osnove metalnih konstrukcija u mašinogradnji, Handbook, Faculty of Mechanical Engineering, Belgrade, 2017
Zoran Petković, Davor Ostrić: Metalne konstrukcije u masinogradji 1, Faculty of Mechanical Engineering, Belgrade 1996.

Material Handlig Equipment

ID: BSc-0264
responsible/holder professor: Zrnić Đ. Nenad
teaching professor/s: Zrnić Đ. Nenad
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: oral
parent department: material handling, constructios and logistics

goals
The basic goal of this subject is to introduce students into the fundamentals of intralogistics (material handling equipment in intralogistics) and to enable achieving practical skills in engineering education and professional work such as are analysis of duty cycle of material handling equipment, selection, sizing and calculation of material handling equipment as elements of material handling and conveying machines.

learning outcomes
Upon successful completion of this course, students should be able to:

- recognize and describe the elements for lifting loads
- choose handling device according to the sort and characteristics of material
- determine the duty service classification of cranes and driving mechanisms
- perform calculation and selection of elements of hoist mechanisms
- perform and selection of elements of travelling mechanisms

theoretical teaching
Introduction into intralogistics and material handling equipment, significance of this field, historical development, classification, types and shapes of materials which have to be handled, application groups, classification into application groups. Elements of driving mechanisms (selection, sizing, calculation), ropes and chains, load handling attachments(hooks, triangular hooks, pulley blocks, slings), sheaves, drums, brakes and arresting gears. Mechanisms for lifting, hand operated hoisting devices (screw-type jack, rack-and-lever jack, hydraulic jack, lever hoist, chain hoist, rope hoist), crane crabs for unit, piece and bulk loads (crane clamps and grabs, carrier beams, electric lifting magnets, vacuum lifters, grab buckets, spreaders), hoists with electric motor, calculation of mechanisms. Mechanisms for translational movement of trolleys and cranes, resistance to motion, wheels, rails, slipping, braking, calculation of mechanism.

practical teaching
Video presentations of machines and principles of material handling equipment operation as well as hoists and cranes. Determination of application groups for hoists and cranes, based on the load spectrum. Calculation of the elements of the drives, calculation of force in rope and chain in slings and pulley blocks. Calculation of drums and shoe brakes. Calculation of lifting mechanism, selection and adoption of application group. Calculation of mechanisms for translational motion, the selection and adoption of application group, calculation and defining the diameter of wheel and rail, checking security against slipping. Laboratory exercises on the computer, 3D modeling of material handling equipment in CATIA software.

prerequisite
Required: Engineering graphics, Materials strength, Materials scinece, Machine elements 1.

Desirable: Machine elements 2.

learning resources

1. Nenad Zrnic: Material handling equipment - Handouts and written lectures, 2011, DVL.

2. Slobodan Tosic, D. Ostric: Cranes, Faculty of Mechanical Engineering, 2005, KDA.

3. Computers, Laboratory 516, ICT / CAH

4. Software package CATIA, ICT / CSP

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
auditory exercises: 15
laboratory exercises: 10
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 5
discussion and workshop: 0
research: 0

knowledge checks: 15
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: 45
laboratory exercises: 15
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

MATHEMATICS

Computational tools

ID: BSc-0930
responsible/holder professor: Cvetković S. Aleksandar
teaching professor/s: Jandrlić R. Davorka, Lazović M. Goran, Radojević Lj. Slobodan, Cvetković S. Aleksandar
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 4
final exam: written
parent department: mathematics

goals
The core of the subject is introducing the concepts of Matlab to the student.

learning outcomes
After finishing the course, students are capable of:

-usage of integers and floating point numbers in Matlab

-usage of data structures in Matlab

-writing programs in Matlab

-reading and writing files in Matlab

-drawing of two and three dimensional figures in Matlab

-symbolic computations (derivatives, integrals, linear and differential equations) in Matlab

theoretical teaching
Matlab working environment. M-file editor. Data types numerical: integers, floating point, complex numbers, operations and relations, logical, operations, logical operations and relations, characters. Data structures: matrix, simple matrices, concatenation, arithmetical series, addressing, changing matrix dimensions, operations, sorting, diagonal matrices, scalars, vectors and empty matrices. Character matrices, comparison, searching and replacing. Date and time. Programming: m-files, branching and cycles, input and output arguments, global and statical variables, anonymous functions and pointers, script files. Elementary mathematics: absolute value and sign, polynomials, linear algebra, trigonometrical, hyperbolic, exponential, power and logarithmic function, statistics. Data I/O: binary files, identifier, reading and writing, machine format, reading and writing characters, information, sequential reading, random access reading and writing, textual files: fprintf, fscanf, reading lines, symbol 't', CSV and DLM files. Graphics: two dimensional, graphic window, drawing with overlapping, aspect ratio, polar and logarithmic graphics, subgraphics, three dimensional graphics, lines, mesh, surfaces,contour plots. Symbolic computation: symbolical objects, symbolic variables and expressions, variables with specific values, matrices, sym. Manipulation with symbolic expressions, simplification, rational expressions, substitution. Analysis, differentiation, integration, limits, sumation, Taylor polynomial, equations: algebraic, differential, linear algebra: matrices, determinants, inverse matrix, reduction and rang, characteristic polynomial, eigenvalues and eigenvectors. Graphics with symbolic expressions.

practical teaching
Matlab working environment. M-file editor. Data types numerical: integers, floating point, complex numbers, operations and relations, logical, operations, logical operations and relations, characters. Data structures: matrix, simple matrices, concatenation, arithmetical series, addressing, changing matrix dimensions, operations, sorting, diagonal matrices, scalars, vectors and empty matrices. Character matrices, comparison, searching and replacing. Date and time. Programming: m-files, branching and cycles, input and output arguments, global and statical variables, anonymous functions and pointers,

script files. Elementary mathematics: absolute value and sign, polynomials, linear algebra, trigonometrical, hyperbolic, exponential, power and logarithmic function, statistics. Data I/O: binary files, identifier, reading and writing, machine format, reading and writing characters, information, sequential reading, random access reading and writing, textual files: fprintf, fscanf, reading lines, symbol 't', CSV and DLM files. Graphics: two dimensional, graphic window, drawing with overlapping, aspect ratio, polar and logarithmic graphics, subgraphics, three dimensional graphics, lines, mesh, surfaces,contour plots. Symbolic computation: symbolical objects, symbolic variables and expressions, variables with specific values, matrices, sym. Manipulation with symbolic expressions, simplification, rational expressions, substitution. Analysis, differentiation, integration, limits, sumation, Taylor polynomial, equations: algebraic, differential, linear algebra: matrices, determinants, inverse matrix, reduction and rang, characteristic polynomial, eigenvalues and eigenvectors. Graphics with symbolic expressions.

prerequisite
No prerequisites.

learning resources
-

number of hours: 45

active teaching (theoretical): 15
lectures: 15
elaboration and examples (revision): 0

active teaching (practical): 25
auditory exercises: 5
laboratory exercises: 20
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks: 5
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: 3
test, with assessment: 0
final exam: 0

assessment of knowledge (maximum number of points - 100)
feedback during course study: 0
test/colloquium: 30
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
A.S. Cvetković, S. Radojević, Matlab I, Mašinski fakultet, Univerzitet u Beogradu, 2012.

Mathematics 1

ID: BSc-1377
responsible/holder professor: Đukić L. Dušan
teaching professor/s: Aranđelović D. Ivan, Đukić Lj. Dušan, Jandrlić R. Davorka, Mutavdžić Đukić M. Rada, Pejčev V. Aleksandar, Radojević Lj. Slobodan, Spalević M. Miodrag, Tomanović D. Jelena, Cvetković S. Aleksandar
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: written+oral
parent department: mathematics

goals
Mastering basics of linear algebra, including analytic geometry, and single variable calculus, theoretically and practically.

learning outcomes
Upon completing this course, the student is expected to:

1. be enabled to work with vectors and matrices and solve systems of linear equations;

2. know how to represent basic geometric objects in the cartesian space and work with them;

3. understand the notion of functions and basic properties thereof, and is acquainted with elementary functions;

4. know basic single variable differential calculus, including limits, asymptotes, local extrema and Taylor polynomials;

5. understand curves represented as traces of vector functions and notions of curvature and torsion.

theoretical teaching
- Matrices

- Systems of linear equations

- Geometric notion of vectors and their representation in coordinates

- Lines and planes in the cartesian coordinate system

- Curves (conics) and surfaces of the second order

- Notion of a function; elementary functions

- Properties and applications of limits

- Derivatives and applications of differential calculus

- Taylor polynomial

- Parametric curves

practical teaching
in accordance with the lectures

prerequisite
defined by the curriculum

learning resources
- "Matematika 1 - udžbenik i zbirka zadataka", Mašinski fakultet, 2020.

- Sources on the web

number of hours: 75

active teaching (theoretical): 35
lectures: 20
elaboration and examples (revision): 15

active teaching (practical): 31
auditory exercises: 25
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 6
discussion and workshop: 0
research: 0

knowledge checks: 9
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: 0
final exam: 3

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: 0
final exam: 50
requirements to take the exam (number of points): 50

references

Mathematics 2

ID: BSc-1183
responsible/holder professor: Pejčev V. Aleksandar
teaching professor/s: Aranđelović D. Ivan, Đukić Lj. Dušan, Jandrlić R. Davorka, Mutavdžić Đukić M. Rada, Pejčev V. Aleksandar, Radojević Lj. Slobodan, Spalević M. Miodrag, Tomanović D. Jelena, Cvetković S. Aleksandar
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: written
parent department: mathematics

goals
The aim of the course Mathematics 2 is to introduce students to basics of the following topics: Indefinite and definite integrals and their applications, differential calculus of real-valued multi-variable functions (wich depend on several independent real variables), first-order differential equations.

learning outcomes
Upon successful completion of this course, students should be able to:

1) Solve indefinite, definite, and improper integrals of real valued functions of a real variable.

2) By applying learned techniques of integral calculus:

to calculate areas in the plane,

to calculate arc length,

to calculate area and volume by rotating an area.

3) Calculate partial derivates - differentiation of the real-valued and vector –valued functions that takes more independent real variables .

4) By applying learned techniques of differentiation calculus:

to find extremas of real valued functions with more independent real variables

to investigates areas defined as hodograph of vector valued functions by application of fractional differentiation

5) Solve differential equations of first order: separable differential equations, homogeneous, linear, Bernoulli differential equations, and differential equation with total differential.

6) By application of learned technique for solving differential equations of first order:

to determine equations of orthogonal and isogonal trajectories to family of one parameter straight lines

theoretical teaching
transcendental functions, definite integral, definition, existence, basic properties, basic theorem of integral calculus, methods of integration of definite integral, improper integrals, quadrature of plane figure, cubature of solid of revolution, rectification of curve, surface of solid of revolution, differential

calculus of real-valued multi-variable functions (which depend on several independent real variables), Taylor's theorem, local extreme values of a function with two independent variables, surface as hodograph of a vector-function depends on two independent variables, tangent plane and normal to surface, first-order differential equations, the method of separation of variables, first-order homogenous differential equations, first-order linear and Bernoulli differential equations, exact differential equations, integration factor, orthogonal and isogonal trajectories.

practical teaching
transcendental functions, definite integral, definition, existence, basic properties, basic theorem of integral calculus, methods of integration of definite integral, improper integrals, quadrature of plane figure, cubature of solid of revolution, rectification of curve, surface of solid of revolution, differential calculus of real-valued multi-variable functions (which depend on several independent real variables), Taylor's theorem, local extreme values of a function with two independent variables, surface as hodograph of a vector-function depends on two independent variables, tangent plane and normal to surface, first-order differential equations, the method of separation of variables, first-order homogenous differential equations, first-order linear and Bernoulli differential equations, exact differential equations, integration factor, orthogonal and isogonal trajectories.

prerequisite
The course attendance condition is determined by the curriculum of study program.

learning resources
Written handouts from lectures in Mathematics 2: Lesson 1, Lesson 2, Lesson 3, Lesson 4, Lesson 5, Lesson 6, Lesson 7, Lesson 8, Lesson 9.

All the necessary literature is on:

http://147.91.27.133 or ftp://147.91.27.133

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
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: 15
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

D. Tošić, M. Albijanić, D. Milenković, Elementi diferencijalnog i integralnog računa, Službeni glasnik, Beograd 2012
S. Nešić: Zbirka zadataka iz matematike 1, Mašinski fakultet, Beograd, 1995
Z. Mamuzić, B. Đerasimović, V. Simonović: Osnovi matematičke analize sa elementima diferencijalne geometrije i računarstva, Naučna knjiga, Beograd, 1991
S. Nešić, R. Radovanović: Zbirka zadataka iz matematike 2, Mašinski fakultet, Beograd, 1990.;
Miodrag M. Spalević, Ivan D. Aranđelović, Dragan J. Doder, Aleksandar V. Pejčev, Dušan Lj. Đukić. Jelena D. Tomanović: Diferencijalne jednačine, Mašinski fakultet Beograd

Mathematics 3

ID: BSc-0672
responsible/holder professor: Spalević M. Miodrag
teaching professor/s: Aranđelović D. Ivan, Đukić Lj. Dušan, Jandrlić R. Davorka, Mutavdžić Đukić M. Rada, Pejčev V. Aleksandar, Radojević Lj. Slobodan, Spalević M. Miodrag, Tomanović D. Jelena, Cvetković S. Aleksandar
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: written
parent department: mathematics

goals
The aim of the course Mathematics 3 is to introduce students to basics of the following topics: Linear differential equations of higher order, linear systems of differential equations, path and line integrals, multiple integrals, scalar and vector fields.

learning outcomes
Upon successful completion of this course, students should be able to:

• Identify and solve certain types of differential equations of higher order, in particular linear differential equations of higher order, solve systems of linear differential equations.

• Determine the frontiers of curves, surfaces and bodies in the plane and space, over which will be carried out the integration of functions of several variables.

• Determine all types of curvilinear, double, triple and surface integrals, both directly and by corresponding substitutions, and using known formulas, by which is easier to calculate.

• Apply lessons learned, and determine derivative in a given direction and the gradient of a scalar field, vector lines, divergence and curl of a vector field, the work and the flow of the vector field, and to carry out the classification of vector fields, determine the length of curves, measure of the surface area, volume of the body.

theoretical teaching
Linear differential equations of higher order, linear systems of differential equations, path and line integrals with applications, double integrals (definition, properties, evaluation, change of variables in double integrals), application of double integrals in computing solid volumes and surface areas, Green's theorem, triple integrals (definition, properties, evaluation, change of variables), improper double and triple integrals, surface integrals (definition, properties, evaluation, Stokes' and Gauss-Ostrogradsky theorems, path independence of line integrals, scalar and vector fields, gradient of a scalar field, vector lines, divergence and curl of a vector field, work and flow of a vector field, classification of vector fields.

practical teaching
Linear differential equations of higher order, linear systems of differential equations, path and line integrals with applications, double integrals (definition, properties, evaluation, change of variables in double integrals), application of double integrals in computing solid volumes and surface areas, Green's theorem, triple integrals (definition, properties, evaluation, change of variables), improper double and triple integrals, surface integrals (definition, properties, evaluation, Stokes' and Gauss-Ostrogradsky theorems, path independence of line integrals, scalar and vector fields, gradient of a scalar field, vector lines, divergence and curl of a vector field, work and flow of a vector field, classification of vector fields.

prerequisite
The course attendance conditions is determined by the curriculum of study program.

learning resources
Written handouts from lectures in Mathematics 3: Lesson 1, Lesson 2, Lesson 3, Lesson 4, Lesson 5, Lesson 6, Lesson 7, Lesson 8, Lesson 9.

M. Spalevic, A. Cvetkovic, I. Arandjelovic, A. Pejcev, D. Djukic, J. Tomanovic: Multiple, curvilinear, surface integrals and applications, series theory, 2015, Faculty of Mechanical Engineering Beograd. (The textbook in Serbian.)

M. Spalevic, I. Arandjelovic, D. Doder, A. Pejcev, D. Djukic, J. Tomanovic: Differential equations, 2017, Faculty of Mechanical Engineering Beograd. (The textbook in Serbian.)

number of hours: 75

active teaching (theoretical): 45
lectures: 25
elaboration and examples (revision): 20

active teaching (practical): 30
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: 0
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: 70
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
M.Krasnov, A. Kiselev, G.Makarenko, E. Shikin: Mathematical Analysis for Engineers, Volume I, II, Mir Publishers, Moscow, 1990.
Larson, Hostetler, Edwards CALCULUS, Lexington, Massachusetts, Toronto, 1990.

Numerical methods

ID: BSc-0673
responsible/holder professor: Cvetković S. Aleksandar
teaching professor/s: Jandrlić R. Davorka, Mutavdžić Đukić M. Rada, Pejčev V. Aleksandar, Spalević M. Miodrag, Tomanović D. Jelena, Cvetković S. Aleksandar
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: oral
parent department: mathematics

goals
The main goal of this subject is to introduce the students with the basics of the numerical and functional series theory and the theory of numerical computation, as well as to demonstrate some implementation of the numerical methods in Matlab.

learning outcomes
After finishing the coursework, students are capable of

- understand convergence of numerical and functional series, methods of approximation using power series

- computing solutions of linear and nonlinear equations, interpolation problem, and ordinary differential equations, in general and using Matlab

- computing approximate values of integrals and derivatives, in general and using Matlab

- estimating the accuracy and precision of the computation.

theoretical teaching
Numerical series. Convergence, divergence. Harmonical series. Series with positive elements. Dalambert and Cauchy convergence criterion. Alternative series. Liebnitz convergence criterion. Absolutely and semiconvergent series. Functional series. Uniform convergence. Weierstreiss theorem. Properties of uniformly convergent series. Potential series. Taylor and Maclaurin series. Trigonometrical series.

Absolute and relative error. Number representation. Floating point representation. Significant digits. IEEE-754-2008. Classes single and double in Matlab. MAchine precision. Arithmetic operations with rounded numbers and error propagation. General function computation with approximate arguments. Computation stability. Ill conditioning.

Vector and matrix norms. Linear systems. Gauss method. LU decomposition. Solving linear systems in Matlab. Iterative methods for linear systems. Gauss-Seidel method. Interpolation. Lagrange and Newton interpolation polynomial. Error analysis and Lebesgue function.

Numerical differentiation. Interpolation and differentiation in Matlab. One and two side methods. Error in numerical differentiation. Numerical differentiation in Matlab.

Nonlinear equations and systems. Newton method. Newton-Kantorovich method. Convergence analysis and order of the iterative method.

Solution of nonlinear equations in Matlab. Numerical integration. Newton-Cotes quadrature rules. Numerical integration in Matlab. Error of numerical integration.

Ordinary differential equations. Cauchy problem. Euler's method. Explicit and implicit methods (Adams-Bashforth, Adams-Moulton). Runge-Kutta methods. Solving ODE in Matlab.

practical teaching
Series. Comparison convergence criterion. Dalambert and Cauchy convergence criterion. Alternative series. Liebnitz convergence criterion. Absolutely and semiconvergent series. Functional series. Uniform convergence. Weierstreiss theorem. Properties of uniformly convergent series. Potential series. Expansion in potential series. Trigonometrical series.

Absolute and relative error. Number representation. Floating point representation. Significant digits. IEEE-754-2008 and function num2hex. Classes single and double in Matlab. Machine precision and function eps. Cancelation of significant digits during computation. Function computation with approximate argument values. Computation stability. Ill conditioning.

Norms of vectors and matrices. Linear systems. Gauss method and LU decomposition implementation. Function linsolve. Matrix inversion and operators \ and /. Pivoting. Matrix condition number and conditioning of the system od linear equations. Iterative methods for linear systems. Jacobi and Gauss-Seidel method implementation. Convergence analysis.

Interpolation. Implementation of different methods of interpolation and function interpo1 in Matlab. Interpolation error and Lebesgue function.

Numerical differentiation. Implementation of numerical differentiation and function diff. One sided and two sided methods. Error of interpolation and Lebesgue function.

Nonlinear equations and systems of equations. Newton's method. Implementation of Newton's method. Convergence analysis and order of the iterative method.

Numerical integration and function integral. Trapezoidal rule and function trapz. Error of numerical integration.

Solving ODE. Implementation to linear multistep methods and function ode113. Runge-Kutta methods and function ode45.

prerequisite
No prerequisites.

learning resources
Literature:

A.S. Cvetković, M.M. Spalević, Numerical methods, Faculty of Mechanical Engineering, University of Belgrade, 2013.

M.M. Spalević, A.S. Cvetković, I. Aranđelović, A. Pejčev, D. Đukić, J. Tomanović, Multiple, line and surface integrals, series, Faculty of Mechanical Engineering, University of Belgrade, 2015.

Software:

Matlab.

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
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: 15
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): 21

references

A.S.Cvetković M.M. Spalević, Numeričke metode, Mašinski fakultet, Unvierzitet u Beogradu, 2013.
M.M. Spalević, A.S. Cvetković, I. Aranđelović, A. Pejčev, D. Đukić, J. Tomanović, Višestruki krivolinijski i površinski integrali i primene, teorija redova, Mašinski fakultet, 2015.

Programming in C

ID: BSc-0670
responsible/holder professor: Radojević L. Slobodan
teaching professor/s: Jandrlić R. Davorka, Lazović M. Goran, Radojević Lj. Slobodan, Cvetković S. Aleksandar
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 4
final exam: written
parent department: mathematics

goals
The main objective of this course is to introduce students to the use C as programming language. It will be especially prominent characteristic to use C in

Mechanical Engineering, characterized by analysis of the data collected in real time.

Students must be:

• familiar with the data types and data structures;

• identify common use of the programming language C;

• use basic commands and C, and with their help solve simple engineering problems;

• familiar with using C for the analysis of data characteristic of Mechanical Engineering;

• familiar with basic programming techniques, which are characterized not only C.

learning outcomes
After successful completion of the course, students can:

• to recognize the possible use of C programming language to solve some problems in Mechanical Engineers.

• to gain basic knowledge of the principles of programming in C;

• to use the file.

theoretical teaching
Types and sizes of data. Constants.

Operators. Priority and order of calculation.

Statements and blocks.

Branch instruction program.

Loop.

Unconditional jump commands.

Basic concepts of functions. External variables. Policies range.

Using files.

practical teaching
Workshops with basic examples in C.

prerequisite
A high school mathematics and programming.

learning resources
The necessary software for this course is under the GNU license - free of charge.

If you use Linux then you C/C++ is available immediately.

If you are using another operating system, C/C++ can be downloaded from the corresponding web site (see URL) or the URL.

To run the software necessary to possess enough simplest PC.

number of hours: 45

active teaching (theoretical): 15
lectures: 12
elaboration and examples (revision): 3

active teaching (practical): 20
auditory exercises: 5
laboratory exercises: 10
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 5
research: 0

knowledge checks: 10
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: 2
test, with assessment: 0
final exam: 3

assessment of knowledge (maximum number of points - 100)
feedback during course study: 10
test/colloquium: 10
laboratory exercises: 30
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 50
requirements to take the exam (number of points): 50

references
The C programming Language, Dennis M. Ritchie, Brian W.Kernighan, ISBN 0-13-110362-8

MECHANICS

Biomechanics of locomotor system

ID: BSc-0800
responsible/holder professor: Lazarević P. Mihailo
teaching professor/s: Lazarević P. Mihailo
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 4
final exam: oral
parent department: mechanics

goals
To introduce students to the application of fundamental principles and laws of biomechanics to understand and study human locomotor system (HLS) - prediction of functional motion / movement, human posture. The formation of the corresponding models of HLS, the possibility of simulations based on them in order to confirm the experimental data, its application to rehabilitation purposes. It allows the potential cooperation with experts in medicine, sports, etc. or work in specialized clinical institutions.

learning outcomes
•Applying the basic principles and laws of mechanics/biomechanics in order to understand and study human locomotion system (HLS)

•Determine anthropometric values of HLS

•Identify the most significant biomechanical properties of muscles, bones, ligaments, tendons, lung, cardiovascular system

•Forming biomechanical muscle models (Hill's musclemodel, ...)

•Forming simpler kinematical/dynamical biomechanics models HLS, during (standing), walking, running,

• Numerical simulate the previously formed biomechanical models using programming environment (MATLAB, etc.)

• Analyzing energy aspects of HLS

• Choose the appropriate hip endoprosthesis on the previously conducted biomechanical analysis

theoretical teaching
The basic concepts of anthropometry and elements of functional anatomy, biomechanics of human limbs and other functional parts of the human body. Biomechanical properties of bones, muscles, joints, tendons and ligaments. Biomechanics of the shoulder, elbow, hand, spine, hip, foot:rheological models. Statics of musculoskeletal system of humans. The concept of locomotion, types of locomotions.Kinematics of the human locomotor system (HLS) and motor tasks. The task of direct and inverse dynamics of HLS. Motion,the energy aspects of: work, energy, power. Biomechanics of internal organs and organ systems.Basic concepts of tissue biomechanics. Fundamentals of kinematic mechanisms. Model mechanism of HLS in the form of kinematic chains with branching-differential equations of motion (DIFE)-example of the upper body;example of closed kinematic chain: bipedal locomotion. Biomechanics of walking/bipedal locomotion. Orthopaedic biomechanics.

practical teaching
Examples of determining anthropometric data. Models of muscle: skeletal,smooth, cardiac, bone models, the spinal column. Examples of solving the problems of kinematics and dynamics of the HLS. Energy analysis and stress analysis: various examples. Example of the cardiovascular, nervous and respiratory systems. Examples of biomechanical models of organs. Instances of models of HLS in the

form of kinematic chains-different cases. Mathematical modeling of human body motion and interaction with the environment. Examples of locomotor motion: walking, running, sports movements. Computer methods and techniquesin biomechanics (FEM, Matlab,...) with the appropriate application. Biomedical measurements, instrumentation and equipment. Examples of models of prosthetic/ orthotic mechanisms of-applications in rehabilitation. Various problems of HLS.

prerequisite
desirable courses: Mechanics 1, Mechanics 2, Mechanics 3, Fundamentals of biomedical engineering, Human anatomy and physiology

learning resources
[1]Y.Fung,Biomechanics:Mechanical Properties of Living Tissues,Springer,2000.(KSJ)

[2]Winter,D.A.Biomechanics of Human Movement,John Wiley&Sons,1990.(KSJ)

[3]Nordin M,Frankel V,Basic biomechanics of the musculoskeletal system,Lea &Febiger,London,1980.(KSJ)

[4]Tozeren A.Human Body Dynamics-Classical Mechanics and Human Movement, Springer Verlag,2000.(KSJ)

[5]Lazarević, M. Basics Biomechanics, (script in preparation),2011.

[6] Written abstracts from the lectures (Handouts)

[7] Cyberbotics Webots - software simulation package

[8]MATLAB,CATIA,software packages(CSP,SSO)

number of hours: 45

active teaching (theoretical): 18
lectures: 8
elaboration and examples (revision): 10

active teaching (practical): 17
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: 10
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

Duane Knudson,Fundamentals of Biomechanics,Springer Science+Business Media, LLC,2007.
D. Schneck, J. Bronzino,Biomechanics : principles and applications, CRC PressLLC,2003.
Y. Hong and R. Bartlett,Routledge Handbook of Biomechanics and Human Movement Science,Routledge,2008.
C. Oomens, M. Brekelmans, F. Baaijens,Biomechanics: Concepts and Computation,Cambridge University Press,,2009
S. Cowin, S. B.Doty,Tissue Mechanics, Springer Science+Business Media, LLC,2007

Mechanics 1

ID: BSc-0001
responsible/holder professor: Mladenović S. Nikola
teaching professor/s: Zorić D. Nemanja, Jeremić M. Olivera, Lazarević P. Mihailo, Mandić D. Petar, Mitrović S. Zoran, Mladenović S. Nikola, Obradović M. Aleksandar, Radulović D. Radoslav, Tomović M. Aleksandar, Trišović R. Nataša
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: oral
parent department: mechanics

goals
-to provide students knowledge of the fundamental principles of Statics

-to enable students to master the reduction of system to the simple form and determining conditions of equilibrium of the force system

-to prepare students for solving the problems in different engineering and scientific fields

learning outcomes
Upon successful completion of this course, students will be able to:

•Apply the principle of liberation from constraints of constrained body exposed to action of forces

•Form conditions of equilibrium and determine unknown forces in case of concurrent forces system

•Set conditions of equilibrium and determine unknown forces and torques in case of forces system in plane and in space and couples system

•Determine basic static quantities (normal-force, shear-force and bending-moment) in a cross-section of beams and frames as well as depict their diagram

•Solve static problems regarded to sliding friction and rolling friction

•Determine center of gravity of a body

theoretical teaching
Statics in Engineering. Basic Concepts. Axioms of Statics. Constrained Body. Constraints and Reactions of Constraints. Constraint Removal Principle. Conditions of Equilibrium of Concurrent Force System. Equilibrium of Three-force System. Moment of a Force about a Point and Axis. Couple. Moment of a Couple. Equivalence of Couples. Equilibrium of Couple Systems. Fundamental Theorems of Statics. Reduction of Force Systems. Condition of Equilibrium of Force Systems. Center of Parallel Force System. Center of Gravity of a Body. Center of Gravity Determination. Guldin's Theorems. Types of Loads. forces and Moments in Cross-section of Structures. Plane Structres. Free Body Diagrams. Plane Trusses. Friction. Real Constraints. Rolling resistance.

practical teaching
Conditions of equilibrium of concurrent force system. Equilibrium of Three-force system, Conditions of Equilibrium of Force Systems. Center of Gravity of a Body. Center of Gravity Determination. Guldin's Theorems. Forces and Moments in Cross-section of Structures. Plane Structures. Free Body Diagrams, Plane Trusses. Friction. Real Constraints. Rolling resistance.

prerequisite
no

learning resources

[1] Golubović, Z., Simonović, M., Mitrović, Z., Mechanics - Statics, Faculty of Mechanical Engineering, Belgrade, 2007.

[2] Glišić, M., Trišović, N., Jeremić, O., Milićev, S., Zeković, D., Collection of examples from Statics with appendix in theory, Faculty of Mechanical Engineering, Belgrade, 2007.

[3] Handouts

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
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: 15
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

Lukačević, M., Čović, V., Statics, Gradjevinska knjiga, 1996.

Mechanics 2

ID: BSc-1172
responsible/holder professor: Jeremić M. Olivera
teaching professor/s: Zorić D. Nemanja, Jeremić M. Olivera, Lazarević P. Mihailo, Mandić D. Petar, Mitrović S. Zoran, Mladenović S. Nikola, Obradović M. Aleksandar, Radulović D. Radoslav, Tomović M. Aleksandar, Trišović R. Nataša
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: oral
parent department: mechanics

goals

-to provide students knowledge of the fundamental principles of Kinematics and Particle Dynamics

-to enable students to master the determination of motion, properties of motion of mechanical objects and determination the causes of motions

-to prepare students for solving the problems in different engineering and scientific fields

learning outcomes

Upon successful completion of this course, students will be able to:

•Analyze motion of a particle in various coordinate systems

•Solve problems related to kinematics of a particle, i.e. to determine line of motion, trajectory, velocity, acceleration and sector velocity

•Describe certain types of body motion: translation, rotation of a body about a fixed line, plane motion, spherical motion and general motion of a rigid body, as well as to determine kinematic quantities of a body (angular velocity and angular acceleration) and to determine velocity and acceleration of some points of a body

•Solve kinematic problems related to the relative motion of a particle

•Set differential equation related to the motion of a free and constrained particle, as well as to solve direct and inverse dynamic problem of a particle

•Determine center of mass and inertia moments of a particle system and a rigid body

theoretical teaching

Basic Concepts of Kinematics. Determination of Motion of a Particle – Vector and Natural. Particle Velocity. Determination of Particle Velocity in Various Types of Coordinate Systems. Particle Acceleration. Determination of Particle Acceleration. Basic Terms of Kinematics of a Rigid Body. Translation. Rotation of a Rigid Body about a Fixed Axis. Angular Velocity and Angular Acceleration of a Rigid Body. Planar Kinematics of a Rigid Body. Spherical Kinematics of a Rigid Body. Relative Motion of a Particle. Velocity and Acceleration of a particle in Relative Motion. Free Particle Dynamics. Direct and Inverse Tasks of Dynamics. System of Particles. Constraints. Euler's and Lagrange's equations of Motion of a Particle. Center of Inertia. Moments of Inertia.

practical teaching

Determination of Motion of Particle – Vector and Natural. Determination of Particle Velocity in Various Types of Coordinate Systems. Determination of Particle Acceleration. Translation. Rotation of a Rigid Body about a Fixed Axis. Angular Velocity and Angular Acceleration of a Rigid Body. Planar Kinematics of a Rigid Body. Spherical Kinematics of a Rigid Body. Velocity and Acceleration of a Particle in Relative

Motion. Free Particle Dynamics. System of Particles. Constraints. Euler's and Lagrange's equations of Motion of a Particle. Center of Inertia. Moments of Inertia.

prerequisite
Defined by curriculum.

learning resources
[1] Mladenović, N., Mechanics 2, Kinematics, Faculty of Mechanical Engineering, Belgrade, 1996.

[2] Simonović, M., Mitrović, Z., Golubović, Z., Mechanics - Kinematics, Faculty of Mechanical Engineering, Belgrade, 2011.

[3] Mladenović, N., Mitrović, Z., Stokić, Z., Collections of examples for Kinematics, Faculty of Mechanical Engineering, Belgrade, 2007.

[4] Mitrović, Z., Simonović, M., Golubović, Z., Mechanics - Dynamics of particle, Faculty of Mechanical Engineering, Belgrade, 2011.

[5] Trišović, N., Lazarević, M., Practicum for Mechanics, Statics and Kinematics, Faculty of Mechanical Engineering, Belgrade, 1999.

[6] Handouts

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
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: 15
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

Rusov, L., Kinematics, Naučna knjiga, 1983.
Đurić, S., Kinematics, Faculty of Mechanical Engineering, Belgrade, 1990.
Pavišić, M., Stokić, Z., Trišović, N., Practicum for Mechanics, Particle Dynamics. Mechanical System Dynamics, Faculty of Mechanical Engineering, Belgrade,1998.

Mechanics 3

ID: BSc-0799
responsible/holder professor: Obradović M. Aleksandar
teaching professor/s: Zorić D. Nemanja, Jeremić M. Olivera, Lazarević P. Mihailo, Mandić D. Petar, Mitrović S. Zoran, Mladenović S. Nikola, Obradović M. Aleksandar, Radulović D. Radoslav, Tomović M. Aleksandar, Trišović R. Nataša
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: oral
parent department: mechanics

goals
-to provide students knowledge of the fundamental principles of Particle Dynamics and Mechanical System Dynamics

-to enable students to master the basic theorems and laws of Mechanical System Dynamics, basic concepts of linear vibration of a particle and elements of Analytical Mechanics

-to prepare students for solving the problems in different engineering and scientific fields

learning outcomes
Upon successful completion of this course, students will be able to:

•Form expressions for momentum and angular momentum of a particle, a system of particles and a rigid body

•Determine kinetic energy of a particle, a system of particles and a rigid body

•Apply impulse-linear momentum theorem, angular impulse-angular momentum theorem and work-kinetic energy theorem of a particle, a system of particles and a rigid body

•Solve motion problems of a particle under central force

• Solve problems of linear straight line vibrations of a particle

•Analyze dynamics of relative motion of a particle

•Form differential equations and solve direct or inverse dynamic problem for translation, for rotation about fixed axe and for planar motion of rigid body

•Apply general equation of statics, general equation of dynamics and Lagrange equations of the first kind on rigid bodies systems

theoretical teaching
Linear Momentum of a Particle and a Mechanical System. Impulse. Impulse-Linear Momentum Theorem and Law of Conservation of Linear Momentum. Angular Momentum of a Particle and a Mechanical System. Angular Impulse-Angular Momentum Theorem and Law of Conservation of Angular Momentum. Differential and Total Work of a Force. Force Field. Force Function. Conservative Force. Kinetic Energy of a Particle and a Mechanical System. Work-Kinetic Energy Theorem and Law of Conservation of Kinetic Energy of a Particle and a Mechanical System. Central Force. Conservation of the Areal Velocity. Differential Equations of Motions for a Particle subjected to Central Force. Binet Equation. Motion of a Particle subjected to Newtonian Gravity. Keplerâ□□s Laws. Dynamics of Relative Motion of a Particle. Linear Vibration of a Particle. Free and Forced. Damped and Undamped Vibration of a Particle. D'Alamber Principle. Differential Equation of Motions of a Rigid Body (Translation, Rotation about a Fixed Axis, Planar and Spherical Motion of a Rigid Body). Basics of Analytical Mechanics.

practical teaching
Impulse-Linear Momentum Theorem and Law of Conservation of Linear Momentum. Angular Impulse-Angular Momentum Theorem and Law of Conservation of Angular Momentum. Differential and Total Work of a Force. Force Field. Kinetic Energy of a Particle and a Mechanical System .Work-Kinetic Energy Theorem and Law of Conservation of Kinetic Energy of a Particle and a Mechanical System. Central Force. Conservation of the Areal Velocity. Differential Equations of Motions for a Particle subjected to Central Force. Binet Equation. Motion of a Particle subjected to Newtonian Gravity. Keplerâ□□s Laws. Dynamics of Relative Motion of a Particle. Linear Vibration of a Particle. Free and Forced, Damped and Undamped Vibration of a Particle. D'Alamber Principle. Differential Equation of Motions of a Rigid Body (Translation, Rotation about a Fixed Axis, Planar and Spherical Motion of a Rigid Body). Basic of Analytical Mechanics.

prerequisite
Defined by the curriculum study program

learning resources
[1] Mitrović, Z., Simonović, M., Golubović, Z., Mechanics - Dynamics of particle, Faculty of Mechanical Engineering, Belgrade, 2011.

[2] Pavišić, M., Golubović, Z., Mitrović, Z. Mechanics - Dynamics of mecnanical systems, Faculty of Mechanical Engineering, Belgrade, 2011.

[3] Vuković, J., Simonović, M., Obradović, A., Marković, S., Collections of examples for Dynamics, Faculty of Mechanical Engineering, Belgrade, 2007.

[4] Handouts

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
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: 15
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

Đurić, S., Dynamics and theory of Vibrations, Faculty of Mechanical Engineering, Belgrade, 1987.
Rusov, L., Dynamics, Naučna knjiga, 1988.

Theory of Mechanical Vibrations

ID: BSc-0012
responsible/holder professor: Obradović M. Aleksandar
teaching professor/s: Zorić D. Nemanja, Jeremić M. Olivera, Lazarević P. Mihailo, Mandić D. Petar, Mitrović S. Zoran, Mladenović S. Nikola, Obradović M. Aleksandar, Radulović D. Radoslav, Tomović M. Aleksandar, Trišović R. Nataša
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
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
Upon successful completion of this course, students will be able to:

•Determine equilibrium position of conservative mechanical system with finite number of degrees of freedom.

•Form differential equations of motions of small mechanical vibrations of a mechanical system about the equilibrium position in matrix form (determine generalized mass, stiffness and damping matrices, as well as vector of generalized forces transformed on Fourier series).

•Analyze free and forced, as well as damped and undamped linear mechanical vibrations, in a clear observation of phenomena in linear mechanical vibration as well as resonance, beating and the dynamic absorber).

•Calculate (analytical and numerical) quantities which characterize vibration processes: natural frequencies, amplitudes, phase angles, logarithmic decrements and modal matrix.

•Determine equations of motion in analytical form using software (Matlab...) for systems with large number of degrees of freedom.

•Describe free undamped mechanical vibrations of elastic bodies with 1-D mass distribution with appropriate partial differential equations, for cases of longitudinal, torsion and lateral vibrations.

•Numerically solve characteristic equation for various cases of boundary conditions and determine angular frequencies. Determine analytical solutions of appropriate partial differential equations in simpler cases initial and boundary conditions.

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
The subject can take students who have made a condition for entry into the third year of study.

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: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
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: 15
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

Rao S.S.: Mechanical vibrations, Addison-Wesley Publishing Company Inc., 1995.
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.

MOTOR VEHICLES

- Fundamentals of Motor Vehicles
- Vehicle Design 1
- Vehicle Dynamics
- Vehicle systems
- Vehicles Safety

Fundamentals of Motor Vehicles

ID: BSc-0869
responsible/holder professor: Mitić R. Saša
teaching professor/s: Blagojević A. Ivan, Mitić R. Saša
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: written+oral
parent department: motor vehicles

goals
Aims of this course include achieving of competences for conquering the basic specific knowledge and skills needed for overviewing and understanding of problems of motor vehicles, their functioning, basic systems, as well as vehicle`s drag and dynamic characteristics in particular environment conditions.

learning outcomes
After successful completition of this course, students should be trained to:

- Recognize basic categories and characteristics of vehicles;

- Review and analyze the characteristics of vehicle systems and components;

- Explain vehicle design concept and analyze existing concepts;

- Define and explain forces acting on a vehicle in motion;

- Describe force distribution in tyre–surface contact;

- Identify characteristic parameters needed to determine adhesion, sliding and rolling resistance;

- Recognize modern vehicle electronic systems and to assess their influence on traffic safety.

theoretical teaching
Theoretical part of course consist of the following units: Introduction: Basic terms, vehicle classification and categorization, vehicle homologation; Concepts of vehicle design, basic systems and elements; Transmission system: construction, tasks and way of functioning – clutch, gearbox, drive axle, final drive, wheels; Suspension and steering system, braking system, support structure; Vehicle propulsion: forces in wheel – surface contact, adhesion coefficient, slip coefficient, determination of reactive forces, power transfer from engine to wheels; Passenger and freight vehicles: maximum performances, power balance, acceleration and braking, vehicle stability; Vehicle safety: safety parameters, electronic systems on vehicle.

practical teaching
Review of basic vehicle classification and categorization; basics of vehicle design concepts; engine; Transmission system – clutch, gearbox, driving axle (review of characteristic examples); Basic vehicle systems – wheels, suspension and steering, braking (review of characteristic examples); View of characteristic examples on specific schemes and on real models.

prerequisite
No special requirements.

learning resources
1. D. Jankovic: Motor Vehicles – Theory and Design, Faculty of Mechanical Engineering, Belgrade, 1993.

2. Handouts

3. Laboratory for Motor Vehicles, Institute for Motor Vehicles.

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
auditory exercises: 23
laboratory exercises: 5
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 2
discussion and workshop: 0
research: 0

knowledge checks: 15
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

D. Jankovic., J. Todorovic, G.Ivanovic, B. Rakicevic: Theory of Vehicle Motion, Faculty of Mechanical Engineering, Belgrade, 2001.
N. Janicijevic, D. Jankovic, J. Todorovic: Design of Motor Vehicles, Faculty of Mechanical Engineering, Belgrade, 2000.

Vehicle Design 1

ID: BSc-0540
responsible/holder professor: Aleksendrić S. Dragan
teaching professor/s: Aleksendrić S. Dragan
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: written
parent department: motor vehicles

goals
Vehicle Design is a complex process, concerned with powertrain, aerodynamics, environmental impact, ergonomics, legislation, materials, production, safety and technology. Course objective is to provide an understanding of the design process of motor vehicles regarding: a) basic requirements being imposed to vehicle and its systems, assemblies, sub – assemblies, and parts, b) influences of vehicle components design on its overall performance, time and cost development, quality of use, and recycling process c) legislation related to the specific vehicle categories. This course aims to develop the broad range of students' skills and knowledge to be able to understand, recognize, and solve complex issues in a vehicle design as a part of challenging automotive industry.

learning outcomes
Course outcomes are development of student's abilities to: a) understand the process of a vehicle design, its relation to design of vehicle systems as well as to be able to design the process to meet desired vehicle/systems characteristics, b) be aware of contemporary issues in vehicle design, c) be able to access various technical information sources, d) be able to function in the team, e) identify key issues, formulate and apply technical knowledge to solve engineering problems related to vehicle design, f) develop written and oral communication skills, g) understand how to use the techniques, skills and modern engineering tools for resolving the problems related to a vehicle design.

theoretical teaching
Theoretical lectures are divided into 13 sections: 1) Introduction – a vehicle design and automotive engineering, 2) New materials and vehicle design, 3) Vehicle design and its production, 4) Vehicle construction and its design, 5) Vehicle design from the point of power sources, 6) Vehicle design and power transmission system (friction clutch, manual and automatic gearboxes, drive shaft, final drive transmission and differentials), 7) Vehicle design from the point of braking system, 8) Vehicle design from the point of suspension system, 9) Vehicle design from the point of steering system, 10) Vehicle design from the point of aerodynamics, 11) Vehicle design from the point of ergonomics, 12) Vehicle design from the point of wheels – tires, 13) Vehicle design from the point of its safety.

practical teaching
Students carry out a group-engineering project. Project is related to critical analysis of design solutions of the given vehicle and its systems. Students have to collect, analysis, synthesis, and present technical information about the design of the given vehicle with aim to understand influence of real design solutions on the vehicle performance and to propose possible improvements of the vehicle design.

prerequisite
There is no precondition.

learning resources
D. Aleksendrić: Vehicle Design 1, Handouts, Faculty of Mechanical Engineering, Belgrade, 2010, DBL.

D. Jankovic, J. Todorovic, G. Ivanovic, B. Rakicevic: Theory of Vehicle Motion, Faculty of Mechanical Engineering, Belgrade, 2000.

N. Janicijevic, D. Jankovic, J. Todorovic: Construction of Motor Vehicles, Faculty of Mechanical Engineering, Belgrade, 2000.

National and international standards, UN/ECE Regulations, EC Directives, related to motor vehicles.

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
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: 15
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

J. H. Smith, An Introduction to Modern Vehicle Design, Butterworth – Heinemann, 2001

Vehicle Dynamics

ID: BSc-0871
responsible/holder professor: Mitić R. Saša
teaching professor/s: Mitić R. Saša, Rakićević B. Branislav
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: written+oral
parent department: motor vehicles

goals
Aims of this course are offering of overall insight in problems of vehicle dynamics, firstly in specific items of wheel – surface contact. This course is intended for the students of Motor Vehicle Module, and represent an introduction for the further exploration of theory of vehicle dynamics. Students are also getting knowledge about incorporating of engine, transmission and driving characteristics into one unit, which is the base for all future activities within the Module.

learning outcomes
After successful completition of this course, students should be trained to:

- List, define and explain forces acting on a vehicle in motion;

- Explain and analyze force distribution in tyre–surface contact;

- Analyze characteristic parameters needed to determine grip, friction, sliding and rolling resistance;

- Discuss and give graphic interpretation of tractive force diagram of the vehicle for defined conditions;

- Explain the influence of transmission parameters on vehicle performance;

- Select transmission elements corresponded to engine performance and road conditions;

- Apply tractive force analysis on transport vehicles and machinery;

- Analyze and explain the consequences of all-wheel drive powertrain related to power circulation.

theoretical teaching
Basic terms – vehicle as dynamic system; forces, momentums, reactive forces; wheel and surface characteristics; forces acting on vehicle – static and dynamic reactive forces – vertical, tractive and side forces; maximum performances – speed, acceleration and slope; engine – characteristics of engines, diagram, transferring of engine characteristics from engine to wheels; equation of movement; dynamic characteristics of passenger, freight and working vehicles – drag diagram, power characteristics, power balance, gear ratios, theoretical and real speed of work vehicles, slip coefficient; Vehicle braking; Fuel consumption characteristics.

practical teaching
Practical lessons are made through public exercise, as preparation for individual students' projects and through practicing some calculations related to all matters studied already in theoretical part. Also, there are autonomous activities of students in calculations within specific areas of course, as well as creation of individual papers, that represent implementation of achieved knowledge for making a dynamic characteristics of vehicles. There is possibility for consultation with teachers, which is preparation for tests and final exam.

prerequisite
No special requirements.

learning resources

1. D.Jankovic, J. Todorovic, G. Ivanovic, B. Rakicevic: Theory of Vehicle Motion, Faculty of Mechanical Engineering, Belgrade, 2001.

2. D. Jankovic: Solved Problems from Motor Vehicles, Faculty of Mechanical Engineering, Belgrade, 1991.

3. D. Jankovic: Instructions for Dynamic Calculation of Motor Vehicles, Faculty of Mechanical Engineering, Belgrade, 1992.

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
auditory exercises: 4
laboratory exercises: 0
calculation tasks: 19
seminar works: 0
project design: 5
consultations: 2
discussion and workshop: 0
research: 0

knowledge checks: 15
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: 20
laboratory exercises: 0
calculation tasks: 20
seminar works: 20
project design: 0
final exam: 30
requirements to take the exam (number of points): 36

references

Thomas D. Gillespie: Fundamentals of Vehicle Dynamics, SAE.
Reza N. Jazar: Vehicle Dynamics: Thaory and Applications, Springer, 2008.
Dean Karnopp: Vehicle Stability, Marcel Dakker, 2004.

Vehicle systems

ID: BSc-1029
responsible/holder professor: Aleksendrić S. Dragan
teaching professor/s: Aleksendrić S. Dragan, Blagojević A. Ivan
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: written
parent department: motor vehicles

goals
Course objectives are to provide a comprehensive insight into the construction of motor vehicles. Providing knowledge related to constructive characteristics of systems, assemblies, and parts of motor vehicles as well as principles of their operation. Students should be able to understand the basic principles of motor vehicle systems operation, their primary tasks, and influence of solutions in the construction of motor vehicle systems on its overall behaviour.

learning outcomes
Course outcomes are development of student's abilities to understand construction of motor vehicles, the role, characteristics, and principles of motor vehicle systems operation. Critical analysis of operation of motor vehicles systems as well as ability to identify the influence of constructive characteristics of a motor vehicle systems, assemblies, and parts on its overall functional characteristic as a whole.

theoretical teaching
Introduction – general about motor vehicles (classification, categotization, unification, and standardization).

Vehicles construction and propulsion; Power transmission systems (friction clutch, manual and automatic gearboxes, drive shaft, final drive transmission and diferentials); Braking system; Tiers, Suspension and steering system; Vehicle body; Electronically controlled systems.

practical teaching
Practical exercises are organized through auditoral explanation and students work in laboratory. Laboratory work is designed to provide students with possibilities to be practically familiarized with each system of motor vehicle as well as its constructive characteristics and principles of operation.

prerequisite
There is no precondition.

learning resources
N. Janicijevic, D. Jankovic, J. Todorovic. Construction of Motor Vehicles, Faculty of Mechanical Engineering, Belgrade, 2000.

D. Aleksendrić. Vehicle systems, Handouts, Faculty of Mechanical Engineering, Belgrade, 2016, DBL.

I. Blagojevic. Vehicle systems, Handouts, Faculty of Mechanical Engineering, Belgrade, 2016, DBL.

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
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: 15
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: 30
laboratory exercises: 30
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 0

references

H. Heisler, Advanced Vehicle Technology, Butterworth – Heinemann, 2002
T.K. Garrett, W. Newton, W. Steeds, The Motor Vehicle, Butterworth – Heinemann, 2001
J. H. Smith, An Introduction to Vehicle Design, Butterworth – Heinemann, 2001

Vehicles Safety

ID: BSc-0504
responsible/holder professor: Rakićević B. Branislav
teaching professor/s: Aleksendrić S. Dragan, Blagojević A. Ivan, Mitić R. Saša, Rakićević B. Branislav
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: written+oral
parent department: motor vehicles

goals
Course objectives are to provide knowledge, skills, and competencies relating to safety-related vehicle systems and fundamental understanding of their operation and performance. Students should be able to understand and solve complex engineering issues in order to increase motor vehicle safety as the most important requirement imposed to automotive industry.

learning outcomes
After successful completion of this course, students should be trained to:

- Explain synergetic influences of systems responsible for vehicle safety on parameters of active, passive and catalytic safety of motor vehicles;

- Analyze the functioning of safety systems on vehicles related to insufficiently determined operating conditions, and possible driver confusion while systems work;

- Analyze safety systems limits and their influence on a driver, vehicle and traffic;

- Solve different case study problems related to vehicle safety;

- Explain force distribution in tyre–surface contact, as well as physical limits of this forces responsible for vehicle movement and behaviour.

theoretical teaching
(1) Introduction (terms and definitions); System driver – vehicle – environment (road); Intelligent traffic solutions; (2) Vehicle safety as a part of traffic safety; (3) Requirements imposed to motor vehicles from the driver and environment point of view; (4) Influencing parameters on motor vehicles safety; (5) Concept, mission, tasks, operation, and performance of safety related vehicle systems; (6) Vehicle stability versus an interaction and load distribution between wheels and road surfaces during braking, driving, and steering in different driving situations; (7) Ecological aspects of vehicle safety; (8) Advanced driver assistance systems and motor vehicle safety; (9) Mechatronic solutions for safety-related motor vehicle systems; (10) Regulations and directives in motor vehicles safety.

practical teaching
(1) Introduction to a project; (2) Project related to critical analyses of safety aspects of motor vehicles with the aim to collect, analyse, synthesise, and present technical information about active and/or passive and/or catalytic safety of the given vehicle; (3) Calculation tasks related to forces in wheel–surface contact and vehicle stability during braking, driving and turning; (4) Analysis of characteristic examples related to implementation of electronically controlled systems on vehicles; (5) Ecological aspects of vehicle safety; (6) Analysis of regulation and directives related to vehicle safety; (7) Guidelines and instructions for regulations related to safety of special purpose vehicles (ADR – vehicles intended for transport of dangerous goods...). (8) Visit and demonstration of check procedure of vehicle safety at station for periodical technical inspection.

prerequisite
No special requirements.

learning resources

1, D. Jankovic, J. Todorovic, G.Ivanovic, B. Rakicevic: Theory of Vehicle Motion, Faculty of Mechanical Engineering, Belgrade, 2001.

2, N.Janicijevic, D. Jankovic, J. Todorovic: Design of Motor Vehicles, Faculty of Mechanical Engineering, Belgrade, 2000.

3, National and international standards, UN Regulations, EC Directives, related to motor vehicles safety

4, Handouts

5, Technical documentation from leading world manufacturers

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
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: 15
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): 36

references

G. Peters, B. Peters, Automotive Vehicle Safety, Taylor & Francis, 2002.
M. Huang, Vehicle Crash Mechanics, CRC Press, 2002.
D. Karnopp, Vehicle Stability, CRC Press, 2004.

NAVAL SYSTEMS

- Buoyancy and Stability of Ship 1
- Ship equipment
- Ship Structures 1
- Ship systems

Buoyancy and Stability of Ship 1

ID: BSc-0693
responsible/holder professor: Bačkalov A. Igor
teaching professor/s: Bačkalov A. Igor
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: written+oral
parent department: naval systems

goals
To cover the basic knowledge of Naval Architecture connected to ship form, ship buoyancy, stability, and ship hydrostatic calculations (hydrostatic curves and stability). Buoyancy and stability is one of the basic professional courses hence taught in all the departments (faculties) with courses in naval architecture.

learning outcomes
Practical knowledge in ship line plan drawing, and in the basic hydrostatic calculations (hydrostatic curves, stability cross curves, righting arm). Ability in solving and analysis of practical engineering tasks connected to ship buoyancy and stability.

theoretical teaching
Geometry of ship hull: basic definitions and principal dimensions, coefficients of form, the lines drawing, hydrostatic curves. Initial stability of ship: righting moment, metacentric height, metacentric radius, angle of static heel, impact of wind, turning and towing, shifting loads, hanging loads and liquid cargo, dynamic stability. Longitudinal stability of ship: trim and longitudinal shifting loads. Intact stability of ship at large angles of heel: curves of centre of buoyancy, centre of flotation, and metacentre. Cross curves of stability. Righting arm and righting moment curves. Potential energy of stability. Ship with circular, wall-sided and inclined sections. Static and dynamic stability diagram. Angles of static and dynamic capsizing. Practical methods of stability calculation. Parts of ship stability. Asymmetrically loaded ship and ship with negative metacentric height. Ship stability regulations.

practical teaching
Practical problems of ship buoyancy and stability, illustrating the subjects lectured in theoretical syllabus. In addition, students work individually on three classical hydrostatic projects: ship lines drawing, ship hydrostatic curves and ship stability. The projects are completed in the Final Course Report (B.Sc. work), and defended after the sixth semester.

prerequisite
The previous study year completed. Semester 5 enrolled.

learning resources
[1] Milan Hofman: Extracts from lectures (handouts) /In Serbian/

[2] Ribar, B., The Theory of Ship, Faculty of Mechanical Engineering, 1987 /In Serbian/

[3] Igor Bačkalov: Instructions for projects in buoyancy and stability of ship /In Serbian/.

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
auditory exercises: 15
laboratory exercises: 0

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

knowledge checks: 15
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

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

Ship equipment

ID: BSc-0954
responsible/holder professor: Simić P. Aleksandar
teaching professor/s: Simić P. Aleksandar
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 2
final exam: written
parent department: naval systems

goals
The aims of the course are to familiarize students with: 1) basic ship equipment, both with the one found on each ship and with a special one found on some types of ships; 2) essential characteristics of various ship types; 3) regulations concerning ship equipment; 4) the expected development of ship types and their equipment.

learning outcomes
Having successfully mastered the teaching contents of Ship equipment, the student should demonstrate fundamental knowledge about:

1) ship equipment;

2) various types of ships and their essential characteristics;

3) the expected development of ship equipment and ship types etc.

theoretical teaching
In brief, the course comprises the following teaching units:

1) Deck equipment (anchoring, mooring and steering device).

2) Cargo access equipment (for vertical and horizontal cargo handling), ship cranes.

3) Safety equipment (rescue, navigational).

The Ship equipment course gains in importance concerning the fact that ships differ in the first place in the installed equipment. The cost of ship is considerably affected

by the installed equipment. Ship equipment, on the other hand, is not manufactured in the shipyards but is manly purchased from specialized manufacturers. That is, to some extent, the reason why the content of the course is mainly encyclopedic in its character.

practical teaching
The student is in the focus of practical teaching. Attention is directed to the application of knowledge, previously attained by theoretical teaching, and needed for common engineering practice. Emphasis is placed on classification societies' rules related to ship equipment. World leading ship equipment manufacturers' brochures and leaflets provide a source for students to get acquainted with technical characteristics and specificities of equipment installing, depending on the type of ship.

prerequisite
There are no prerequisites

learning resources
Lectures are available in electronic form

Various classification societies' rules

Brochures of various equipment manufacturers

Internet resources

number of hours: 30

active teaching (theoretical): 12
lectures: 8
elaboration and examples (revision): 4

active teaching (practical): 12
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: 6
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: 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): 20

references

D. J. House: Seamanship Techniques, Shipboard and Marine Operations, Elsevier, Oxford, 2004.
L. Buxton, R. Daggitt, J. King: Cargo Access Equipment for Merchant Ships, E&F. N. Spon Ltd. London 1978.

Ship Structures 1

ID: BSc-0071
responsible/holder professor: Motok D. Milorad
teaching professor/s: Momčilović V. Nikola, Motok D. Milorad
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: oral
parent department: naval systems

goals
The aims of the course are to explain the requirements that hull structure has to meet, and as a result, to gain essential understanding of its general conception, to familiarize the student with the hull structural members to the design details level, to develop student skills to practically apply standard engineering methods used for steel hull structure scantling definition.

learning outcomes
A thorough knowledge of general concept and structural members of the welded steel ship hull. The student should be able to practically apply rules for building ships by various classification societies.

theoretical teaching
Theoretical teaching is partially encyclopedic in character. The student becomes familiar with the hull basic structural members (terminology presented in both Serbian and English), appearance, basic functions, and loads they undergo during exploitation, method of fabrication, and their versatility and design, depending on ship type and size, applied framing system and the like. On the other hand, both basic principles and methodology for hull scantling definition are considered in parallel, first of all, from the aspect of strength. The history and today's role of classification societies is considered, their rules and basic aspects of some direct calculations are explained.

practical teaching
A detailed prominent example is used to explain the procedure of hull structure scantling definition according to Lloyd's Register Rules. Within the framework of independent project design the student is dimensioning the following structural members of midship section using "his own" concrete example of the ship: plating and the stiffening system of bottom and inner bottom; plating and the stiffening system of ship sides; plating and the stiffening system of weather and cargo deck; plating and the stiffening system of water-tight bulkheads; pillars in 'tween deck and hold; fore peak structure; after peak structure.

prerequisite
Defined by the Study Program Curriculum

learning resources
[1]Lectures are available in electronic form /In Serbian/

[2] A thorough prominent example of the project

[3] Various classification societies' rules

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
auditory exercises: 12
laboratory exercises: 0

calculation tasks: 0
seminar works: 0
project design: 14
consultations: 4
discussion and workshop: 0
research: 0

knowledge checks: 15
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: 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 structures /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.

Ship systems

ID: BSc-1013
responsible/holder professor: Kalajdžić D. Milan
teaching professor/s: Kalajdžić D. Milan
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 4
final exam: written+oral
parent department: naval systems

goals
To cover the basic knowledge of Marine Engineering connected to ship piping and pumping systems.

learning outcomes
Ability in basic design, calculations and analysis of ship piping and pumping systems: bilge, ballast,emergency, heeling, sanitary, tanker, firefighting systems, etc.

theoretical teaching
Ship piping systems: pressure diagram, piping characteristics, characteristics of marine pumps, joint operation of pumps and a piping, suction head problems. Piping armature. Types of marine pumps. Individual ship systems: Bilge system, emergency system, rescue system; Ballast system; Heeling and trim system; Sanitary systems: system of fresh and sea water, system of waste water. Drainage system. Tanker systems: cargo system, stripping system, tank ventilation, tank cleaning, cargo circulation, cargo heating system. MARPOL Regulations. Firefighting systems: fire detection, fire-fighting systems (water, inert gases, foam, halons).

practical teaching
Principle design and calculations of various ship piping and pumping systems. Practical examples of ship systems, illustrating the subjects lectured in theoretical syllabus.

prerequisite
The second study year completed. Semester 5 enrolled.

learning resources
[1] Extracts from lectures (handouts) /In Serbian/.

[2] Instructions for making tasks from ship systems /In Serbian/.

[3] Technical documentation: Examples of ship systems. Catalogues of marine pumps and armature.

number of hours: 45

active teaching (theoretical): 18
lectures: 12
elaboration and examples (revision): 6

active teaching (practical): 18
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: 9
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: 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): 10

references
R.L. Harrington: Marine Engineering, SNAME 1992
A. Rowen et al: Introduction to Practical Marine Engineering, SNAME 2005

PHYSICS AND ELECTRICAL ENGINEERING

Electrical engineering

Physics and Measurements

Electrical engineering

ID: BSc-1070
responsible/holder professor: Škatarić M. Dobrila
teaching professor/s: Lukić M. Petar, Stojić M. Tomislav, Škatarić M. Dobrila
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
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 electrical engineering and to develop their competence for acquisition of more advanced academic knowledge and skills in scientific, professional and applied areas of mechanical engineering relying on electrical engineering. The students are introduced into basic phenomena, devices and circuits encountered in electrical engineering, and methods for their analysis and basic measurements.

learning outcomes
Upon successful completion of this course student should be able to:

1.theoretically and mathematically describe and incorporate basic concepts, laws, relations and processes of general electrical engineering, i.e., area of electrostatic, electrokinetics, electromagnetism and alternating (sinusoidal) currents;

2.mathematically adequately describe expresses and coupling the various electrical, magnetic, and other physical quantities required for basic engineering modeling of different phenomena and processes in electrical engineering;

3. theoretically and mathematically describe and link the basic concepts in the field of electrical measurements;

4. analyze and engineeringly display the results of direct and indirect laboratory measurements.

5. recognize the connection of mechanical, hydraulic and thermal systems with analogue electrical systems.

Checking of outcomes referred to in points 1), 2), 3) and 5) is carried out through the questions on tests, colloquiums and final exam, or checking student responses to questions. Outcome point 4) is checked by an individual laboratory exercises and the defense of student reports made after the laboratory exercises.

theoretical teaching
Electrostatic (brief historical overview, electrical load, Coulomb's law, electric field, potential and voltage, conductors in an electric field, Gauss's law with applications, dipoles, polarization of dielectrics, capacitors: capacitance, type and application, energy of the electric field); Direct current (current field and its characterization, electrolysis, continuity equation and Kirchhoff's laws, Ohm's law, Joule's law, resistors, ems (electromotive force): its origin and type, electric generators: characteristics and transformation, electric circuits and networks, work and power, basic theorems of electrical circuits); Electromagnetism (magnetic field, basic quantities and laws, concept of magnetic flux and conservation law, Ampere's law on the circulation of the vector of magnetic induction, the materials in the magnetic field, magnetisation field and total current law, the magnetic circuits, electromagnetic induction, inductance coefficients, energy of magnetic field, electromechanical conversion); Alternating (sinusoidal) current (generation, characterization, phasor's approach, power, network analysis methods in steady sinusoidal state); Three-phase circuits.

practical teaching
The selected problems will be solved on auditory exercises. Six laboratory exercises are scheduled: 1. Introduction to basic electrical measuring instruments and principles of their operation. Practical application. 2. Basic measuring in DC circuits: current, voltage, power and resistance. 3. Demonstration of basic electromagnetic's laws and proofing of them by measuring. 4. Basic measuring in AC single phase circuits: current, voltage, power, inductance, capacitance and resistance. 5. Three phase power measurements. 6. Advanced techniques in electrical measuring: digital and computer based measurements.

prerequisite
No specific conditions

learning resources
1. D. Kandic: Electrical Engineering /in Serbian/, Faculty of Mechanical Engineering, Belgrade, 2008, ISBN 86-7083-447-2;

2. D. Škatarić, N. Ratkovic, T. Stojic, P. Lukic: Collection of solved problems in electrical engineering /in Serbian/, Faculty of Mechanical Engineering, Belgrade, 2000, ISBN 86-7083-339-5;

3. P. Lukic,D. Škatarić ,T. Stojic: Electrical Engineering-measurements and experiments, Faculty of Mechanical Engineering, Belgrade, 2019. год , ISBN: 978-86-7083-997-7, CIP: 621.317(075.8)(076)

4. Several versions of the written lecture handouts available on the web-site /in Serbian/: http://nastava.mas.bg.ac.rs/nastava/viewtopic.php?f=29&t=110.

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
auditory exercises: 22
laboratory exercises: 6
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 2
discussion and workshop: 0
research: 0

knowledge checks: 15
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: 0
colloquium, with assessment: 9
test, with assessment: 0
final exam: 3

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): 30

references

Del Toro V., Electrical Engineering Findamentals, Prentice-Hall, New Jersey, 1986;
Milton Gussow, Schaum's outline of theory and problems of basic electricity, McGraw-Hill, New York, 1983.

Physics and Measurements

ID: BSc-0025
responsible/holder professor: Vasić-Milovanović I. Aleksandra
teaching professor/s: Vasić-Milovanović I. Aleksandra, Ilić T. Jelena, Jovanović V. Jasmina, Pavlović P. Vera, Trifković M. Zoran
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: written
parent department: physics and electrical engineering

goals
Understanding of basic physical concepts and laws. Aspects of practical application of these laws. Development of problem solving skills through examples from engineering practice and everyday life by applying basic physics laws. Introduction to main devices and methods of direct and indirect measurements in physics and techniques. Understanding of contemporary methods for measurement result processing.

learning outcomes
Final outcomes:

1) adequate theoretical and mathematical description and interconnection of processes in general physics,

2) adequate mathematical description of physical properties,

3) application of physical laws, relations and processes in solving basic technical problems,

4) theoretical and mathematical description of basic concepts in theory of measurements,

5) application of acquired theoretical knowledge of physics and measurements for laboratory practice,

6) analytical and scientific representation of measurement results in laboratory exercises.

theoretical teaching
Basics of kinematics. Basic laws of dynamics: Newton's second law of motion, law of inertia, law of action and reaction, conservation of momentum. Types of forces. Oscillations. Work. Conservation of energy. Rotation. Pressure. Pressure in stationary fluids. Buoyancy. Streaming of ideal fluids. Thermophysics. Phase changes. Ideal gas. Mechanical waves. Standing waves. Sound. Resonance. Electromagnetic waves. Physical optics. Modern physics. Basic concepts of metrology. Expression of measurements results and measurements uncertainty. Frequently used measurement equipment in technical measurements.

practical teaching
Examples of determination of trajectory, path, velocity and acceleration of the body for motions along a straight and curved line. Application of Newton's second law and conservation of mechanical energy for different types of motion, especially for oscillations. Considering the changes in the system energy under the influence of conservative and nonconservative forces and determination of performed work. Application of conservation of momentum. Solving problems in the field of physics of ideal fluids and gases. Application of energy conservation for stationary flow of ideal fluids, as well as in thermophysics for determination of performed work during different thermodinamical processes. Examples in the field of propagation of transvese and longitudinal mechanical waves. Standing waves in confined environment. Resonance. Wave optics (propagation, refraction, reflection, interference and diffraction of waves in optical part of spectrum). X-ray diffraction on crystal.

prerequisite
Defined by the curiculum of study program/module.

learning resources
1)Handouts of lectures. 2)Collection of solved problems in Physics (authors: J.Ilić, Z.Trifković, J.Jovanović, A.Vasić, V.Pavlović; Faculty of Mechanical engineering, University of Belgrade, Belgrade, 2009). 3)Laboratory handbook for experimental work. 4) Lectures in Physics (V.Georgojević et.al., European Commission, Directorate General for Education and Culture, Tempus project number CD_JEP-16123-2001).

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
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: 15
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: 0
colloquium, with assessment: 6
test, with assessment: 3
final exam: 3

assessment of knowledge (maximum number of points - 100)
feedback during course study: 5
test/colloquium: 50
laboratory exercises: 15
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references
Aničin Božidar, Lectures in Physics 1, Faculty of Mechanical Engineering, Belgrade, various editions.
Olga Žižić, Lectures in Physics 2, Faculty of Mechanical Engineering, Belgrade, various editions.
Olga Žižić, Physics - Collection of Solved Problems, Faculty of Mechanical Engineering, Belgrade, various editions.
Halliday D., Resnick R., and Walker J., Fundamentals of Physics, John Wiley & Sons, 2001
Searway R., Beichner R., Jeweet J., Physics for Scientists and Engineers, Fifth Edition, Editor: John Vondeling, Thomson Learning Inc., 2000

PRODUCTION ENGINEERING

- CAD/CAM SYSTEMS
- Computer Graphics
- Computer simulation and artificial intelligence
- Machine tools
- Manufacturing Technology
- Production technology and metrology
- Shipbuilding Technology
- Tools and Fixtures

CAD/CAM SYSTEMS

ID: BSc-0664
responsible/holder professor: Puzović M. Radovan
teaching professor/s: Mladenović M. Goran, Puzović M. Radovan
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: written
parent department: production engineering

goals
1.Awareness that efficiency of computer use in engineering activities can be accomplished only through integrated systems, such as CAD/CAM systems used in the area of product design and design of manufacturing technology

2. Mastery of theoretical foundations of contemporary CAD/CAM systems structure and operation

3. Acquisition of practical knowledge about using CAD/CAM systems and numerically controlled machine tools programming

learning outcomes
On successful completion of the course, students should be able to:

•Design products using CAD (3D modeling of parts and assemblies).

•Design manufacturing technology of parts using CAD (creating NC-sequences).

•Identify the NC program contents (G-code) for CNC machine tools.

•Apply in practice some of the contemporary CAD/CAM systems for product and

manufacturing technology design.

•Transfer NC program into a control unit of a respective CNC machine tool.

theoretical teaching
Theoretical teaching comprises two teaching units:

1. Problem of work-piece geometrical modeling as a basis of CAD system. Internal, computerized and model development of work-piece means to create prerequisites for using that model as a basis for design of manufacturing technology and for generating control information (CAM) for numerically controlled machine tool. In addition to using conventional numerical control technology, this teaching unit is also considering the application of work-piece computer model as a basis of ''rapid prototyping" by material addition technology

2. Basis, structure and application of conventional languages for programming numerically controlled machines are presented. Studies of geometry description, kinematics, technological demands and post-processor commands lead to the contents and structure of control information for modern computer controlled machine tools. Syllabus also includes studying of APT and EXAPT languages

practical teaching
Exercises are organized in computer rooms and at the Laboratory for machine tools. Using available CAD/CAM software, such as ProEngineer, Autodesk Inventor, Catia, Solid Edge and the like, the student will master the skill of work-piece geometrical model development as well as the skill of generating tool path in making NC program for numerically controlled machine tools. Also, the student will write NC program in APT. Final exercise involves the development of NC program for a concrete work-piece on a concrete machining center. Work-piece is manufactured at the Laboratory for machine tools

prerequisite
This course is strongly linked to the area of production engineering and there are no prerequisites for course attendance

learning resources
Lectures in e-form [In Serbian]. Book: APT language (in serbian. Faculty for Mechanical Engineering), Instructions for performing laboratory exercises [In Serbian]. Instructions for project design [In Serbian]. CA workstation (CAD, CAM, CAE, CAPP, ...), CAD/CAM software package

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
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: 15
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: 9
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): 40

references
Lectures in e-form [In Serbian].
Pavao Bojanic, Radovan Puzovic, Production systems - APT language, Faculty of Mechanical Engineering, Belgrade, 2010
Goran Mladenovic, CAD/CAM Systems - Guide for Creo Parametric, Faculty of Mechanical Engineering, Belgrade, 2019

Computer Graphics

ID: BSc-0663
responsible/holder professor: Jakovljević B. Živana
teaching professor/s: Jakovljević B. Živana, Mladenović M. Goran
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: oral
parent department: production engineering

goals
The objective of this course is that students: obtain fundamental knowledge and skills necessary for advanced application of computer graphics in various engineering activities; master theoretical and mathematical basics of computer graphics; gain necessary knowledge, skills and practical experiences the in development of software applications based on computer graphics; understand basic functional principles and acquire knowledge for advanced usage of computer aided design tools.

learning outcomes
After successfully completing this course, the students should be capable to:

- Apply basic and composite two-dimensional and three-dimensional graphical transformations in various engineering problems solving;

- Carry out the projection of the objects on scene on the projection plane;

- Generate free-form lines and surfaces using Bezier curve and surface and B spline curve and surface;

- Apply clipping and hidden surfaces removal algorithms in various engineering problems solving;

- Generate photo-realistic image in three dimensional graphics and animation.

theoretical teaching
1. Introduction to computer graphics: vector and raster graphics, color models, hardware components for image display

2. Modeling in computer graphics: the role of modeling in graphics pipeline, camera model, coordinate systems in computer graphics, hierarchical modeling, B representation

3. Two-dimensional transformations: translation, rotation, scaling, mirror reflection, order of transformations

4. Three-dimensional transformations: translation, rotation, scaling, mirror reflection, order of transformations

5. Projections: orthographic projection, axonometric projection, isometric projection, perspective, viewpoint transformation

6. Curves and curved surfaces: Bezier curves, B spline, NURBS, Bezier surfaces, B spline surfaces

7. Clipping: algorithms for clipping of points, lines polygons: three-dimensional clipping

8. Visibility: Hidden faces removal

9. Illumination and reflection: light sources, ambient light, diffuse reflection, specular reflection, atmospheric attenuation, shadows

10. Shading: flat, Gouraud, Phong, ray tracing

practical teaching
During exercises student masters practical application of knowledge gained during lectures. Based on programming skills, student writes subroutines, which represent elementary building blocks of computer graphics. While testing programs, students revel the complexity of computer graphics application as well as the principles of solving computer graphics problems. Finally, students are presented with commercial products based on computer graphics application and compare their own solutions with commercial.

prerequisite
Programming basics

learning resources
Jakovljevic Zivana, Computer Graphics, lecture handouts

Computer classroom – each student individually works on a computer

Matlab

Visual Studio 2010

Commercial CAD software

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
auditory exercises: 0
laboratory exercises: 28
calculation tasks: 2
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks: 15
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: 0
test, with assessment: 8
final exam: 5

assessment of knowledge (maximum number of points - 100)
feedback during course study: 5
test/colloquium: 30
laboratory exercises: 25
calculation tasks: 10
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

McConnell, J., J., Computer Graphics: Theory into Practice, Jones & Bartlett Learning, 2006, ISBN: 0763722502

Xiang, Z., Plastock, R., Schaum's Outline of Computer Graphics, McGraw-Hill, 2000, ISBN: 0071357815

Hearn, D., Pauline Baker, M., Computer Graphics, C version, Pearson Education, 2002, ISBN: 817758765X

Agoston, M., K., Computer Graphics and Geometric Modelling - Implmentation and Algorithms, Springer-Verlag Ltd, 2005, ISBN: 1-85233-818-0

Newman, W., M., Sproull, R., F., Principles of Interactive Computer Graphics, McGraw-Hill, 1981, ISBN: 0-07-046338-7

Computer simulation and artificial intelligence

ID: BSc-0404
responsible/holder professor: Babić R. Bojan
teaching professor/s: Babić R. Bojan, Miljković Đ. Zoran, Petrović M. Milica
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: written
parent department: production engineering

goals
The aim of the course is to develop student's ability to model and analyze real system using discrete event simulation along with application of models, analysis of simulation results and comparison of alternative solutions. Artificial intelligence will be understood through models, structure of intelligent agents and machine learning. By using of simulation and software tools students will get knowledge for application of artificial neural networks.

learning outcomes
After the course the students will be able to:

• develop models of manufacturing systems and other discrete systems,

• implement model by using adequate simulation software,

• verify built model,

• evaluate and analyse simulation outputs and compare alternative solutions,

• give suggestions for optimization of real system,

• choose methods based on application of artificial neural networks for solving of engineering problems along with modelling of optimal structure,

• use software for simulation of artificial neural networks and analyse and present obtained results

theoretical teaching
Introduction to discrete event simulation. What is simulation, when it is applicable to use simulation, classification of models, types of simulation, steps in simulation, study, advantages/disadvantages of simulation study. Concept of discrete event simulation, list processing. Simulation package AnyLogic. Application of simulation. Verification and evaluation of simulation models, analysis of output data, comparison of alternative designs of systems. Simulation of manufacturing systems. Artificial intelligence - definitions, basic concepts and paradigms. Knowledge bases, knowledge acquisition, models of learning, searching tree, development of soft-computing, autonomous systems. Structure of artificial neural network (ANN), neuron - processing element, transfer (activation) function. ANN models, learning algorithms, uncertainty of system, non-linearity, estimation, clustering. Application of ANN.

practical teaching
General principles and simulation examples. Simulation of single-chanel systems, event handling. Introdution to softwares for modelling and analysis of real systems based on discrete event simulation (lab work). Artificial neural networks in intelligent systems. Introduction to softwares for simulation of artificial neural networks (lab work). Recognition systems, simulation of systems of artificial neural networks, simulation of mobile robot motion (examples). Homeworks and seminar works dealing with simulation of real systems and application fo artificial neural networks (recognition systems - robot vision; recognition of manufacturing features of mechanical parts; recognition of objects for grasping - robot vision).

prerequisite
Defined by curriculum of study programme/module.

learning resources
(1) B. Babic, COMPUTER INTEGRATED SYSTEMS AND TECHNOLOGIES, Faculty of Mechanical Engineering, 2017,18.1

(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) 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/

(4) B. Babic, Z. Miljković, Handouts, University of Belgrade, Faculty of Mechanical Engineering, 2011, 18.1 /In Serbian/

(5) B. Babic, Z. Miljković, Software "Moodle" for distance learning (http://147.91.26.15/moodle/), University of Belgrade, Faculty of Mechanical Engineering, 2011, 18.13

(6) B. Babic, Z. Miljković, Website for Computer simulation and artificial intelligence(http://cent.mas.bg.ac.rs/nastava/ksivi_mo/KSiVI_2009-2010.html), University of Belgrade, Faculty of Mechanical Engineering, 2011, 18.13

(7) AnyLogic simulation software

(8) Z. Miljković, Software packages for simulation of artificial neural networks - BPnet, ART Simulator; Laboratory CeNT website: http://cent.mas.bg.ac.rs/nastava/ksivi_mo/KSiVI_2009-2010.html, University of Belgrade, Faculty of Mechanical Engineering, 18.13

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
auditory exercises: 0
laboratory exercises: 22
calculation tasks: 0
seminar works: 8
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks: 15
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: 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: 35
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

B. Babic, COMPUTER INTEGRATED SYSTEMS AND TECHNOLOGIES, Faculty of Mechanical Engineering, 2017

J. Banks, J. S. Carson, B. L. Nelson and D. M. Nicol (2005), DISCRETE EVENT SYSTEM SIMULATION, 4th Ed., Pearson Education International Series.

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.

Machine tools

ID: BSc-0916
responsible/holder professor: Živanović T. Saša
teaching professor/s: Živanović T. Saša, Kokotović M. Branko
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: oral
parent department: production engineering

goals
1. Step-by-step perception of concepts and themes related to machine tools.

2. Acquisition of basic knowledge about machine tool primary motion configuration for cutting and deformation processing and configuration of feed motions.

3. Studies of machine tool structures, guides foundations and machine tools testing. 4. Studying and practicing the control and programming of numerically controlled machine tools and making a report on acquired knowledge.

learning outcomes
Upon successful completion of this course students should be able to:

1. Choose environment of machine tools and prepare them for work for specific technological task.

2. Configure primary and feed motion of machine tools.

3. Plan and perform the experiment to test a machine tool and to identify the machining process.

4. Program numerically controlled machine tools.

5. Make selection concept of machine tools and their selection for a certain type of machining.

6. Prepare Technical elaborate and reports about testing and programming of machine tools.

theoretical teaching
New teaching contents:

1. Definition, classification and properties of machine tools. Configuration of machine tools. Learning resources.

2. The machine tools saga.

3. Work diagram of the primary motion of cutting machines and electromechanical drives for primary rotary motion.

4. Energy balance in machines for deformation processing.

5. Work diagram of feed motions in metal cutting machines.

6. Machine tools guides.

7. Electromechanical feed drives.

8. Machine tools testing.

9. Machine tools control and programming.

Elaboration of new teaching contents and instructions for doing the tasks:

1. Work diagram of the primary motion.

2. Dimensioning of press energy accumulators.

3. Work diagram of feed motions.

4. Identification of machine tools guides.

5. Configuring of electromechanical feed drives.

practical teaching

Practical teaching consists of auditorial exercises, laboratory work, home work, seminar work and consultations. It embraces the following units:

1. One auditorial exercise: Resources for studying machine tools.

2. Four laboratory exercises: (1)Handling and manual operating of machine tools and handling of measuring equipment in the Laboratory for machine tools. (2)Identification of the main factors in deformation processing. (3)Machine tools testing. (4)Control and programming of machine tools. Instructions for work are given for each exercise, while forms and reports making are prepared beforehand.

3. Five home works.

4. One seminar work is done about control and programming of machine tools.

5. One consultation.

A report on acquired knowledge of machine tools is prepared in parallel.

Knowledge check comprises: two tests, three colloquiums and final examination.

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. Documents on the website http: //cent.mas.bg.ac.rs/nastava/ma_bsc/index.htm.

2. PRA-1: Practicum in preparation.

3. LPI-1: Three work places with manually controlled machine tools.

4. LPI-2: Three work places with numerically controlled machine tools.

5. LMS-2: One work place for identifying principle factors in processing deformation.

6. LPS-1:.Functional simulators of parallel machines kinematics.

7. LPS-2: Functional simulator for rapid prototyping.

8. ARS-1: System for experimental data acquisition and analysis.

9. W. A. Knight, G. Boothroyd, Fundamentals of Metal Machining and Machine Tools, Third Edition, CRC Press, 2005, ISBN 9781574446593.

10. W. R. Moore, Foundations of Mechanical Accuracy, The Moore Special Tool Company, First Edition, Third Printing, 1999.

11. C. Evans, Precision Engineering: An Evolutionary View, Imprint: Cranfield University Press; 1989, ISBN-13: 9781871315011.

12. M. Weck, C. Brecher, Werkzeugmaschinen 1, Maschinenarten und Anwendungsbereiche,

Springer, 2005, ISBN 10 3-540-22504-8.

13. Yoshimi Ito, Modular design for machine tools, The McGraw-Hill Companies, 2008.

DOI: 10.1036/0071496602

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
auditory exercises: 2
laboratory exercises: 25
calculation tasks: 0
seminar works: 2
project design: 0
consultations: 1
discussion and workshop: 0
research: 0

knowledge checks: 15
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: 0
test/colloquium: 40
laboratory exercises: 0
calculation tasks: 10
seminar works: 10
project design: 10
final exam: 30
requirements to take the exam (number of points): 35

references

N.N, Visionary Manufacturing Challenges for 2020, National Academy Press, Washington, D.C. 1998, ISBN 0-309-06182-2
Suk-Hwan Suh, Seong-Kyoon Kang, Dae-Hyuk Chung, Ian Stroud, Theory and Design of CNC Systems, Springer, 2008, ISBN 978-1-84800-335-4.
L.N. López de Lacalle, A. Lamikiz, Editors, Machine Tools for High Performance Machining, Springer, 2009, ISBN 978-1-84800-379-8.
M. Weck, C. Brecher, Werkzeugmaschinen 2, Konstruktion und Berechnung, Springer 2006, ISBN 10 3-540-22502-1.
A. H. Slocum, Precision Machine Design. Society of Manufacturing Engineers, 1998. ISBN13: 9780872634923.

Manufacturing Technology

ID: BSc-1360
responsible/holder professor: Babić R. Bojan
teaching professor/s: Babić R. Bojan, Miljković Đ. Zoran, Pjević D. Miloš, Popović D. Mihajlo, Puzović M. Radovan
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: oral
parent department: production engineering

goals
The main goal of this course is to emphasize the importance of production technologies in everyday life and to study the basic manufacturing processes and tools. The course begins with an introduction to manufacturing systems. Through lectures, demonstrations and practical applications, the student gets acquainted with various manufacturing processes.

Students get acquainted with the basic metal removal processes: turning, planing, milling, drilling and grinding. Also, the basics of metal shaping processes (bulk metal shaping

and sheetmetal) shaping are considered. The most common unconventional processing methods are studied in detail. Special attention is paid to CNC machines.

learning outcomes
On successful completion of the course, students should be able to:

• Identify different machining systems and relative motion between the tool and the work-piece to apply them in defining the process of manufacturing technology.

• Select the appropriate base elements for metalworking by cutting (turning, drilling, milling and planing).

• Determine the principle factors of metalworking by plastic deformation for the processes of compression, extruding and drawing.

• Describe in brief the possibility of manufacturing technology for a specified product.

theoretical teaching
AT-1: Introduction to manufacturing technology. AT-2: Systems and processes in manufacturing technology. AT-3: Quality system and accuracy of manufacturing. AT-4: Machining by chip removal - turning, drilling, milling, shaping and planing, grinding, etc. Determination of the principle factors of the machining process. AT-5: Non-traditional machining methods: ultrasonic machining, electro-discharge machining, electro-chemical machining and combined methods. AT-6.: Metal forming processes. AT-7: Bulk deformation processes and sheet metalworkong processes. AT-8: Automation in production process.

practical teaching
PA-1: Historical overview of the manufacturing process; PA-2; PA-3; AR-1; PA-4; AP-2; AR-3; PZ-1: A task in machining process; PZ-2: A task in forging; PZ-3: A task in drawing; PL-1: Metalworking machine tools for chip removal (milling machine, Pfauter milling machine, Fellows planer, grinding machine for flat surface and round grinding); PL-2: Metalworking machine tools for chip removal (lathe, planer and radial drill); PL-3: Metalworking machine tools for deformation processes + Finite-element method using the example of MEKELBA package and simulation of metal forming processes – OSA; PL-4: Technology design for CNC machine tools and industrial robots application.

prerequisite
Defined by the Study Program Curriculum.

learning resources
Laboratory machines: lathe, planer, radial drill, milling machine, Pfauter milling machine, grinding machine, machining centers, presses, robots, laboratory for FTS, machining processes and tools.

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
auditory exercises: 5
laboratory exercises: 12
calculation tasks: 13
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks: 15
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: 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: 20
calculation tasks: 20
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

Production technology and metrology

ID: BSc-1165
responsible/holder professor: Puzović M. Radovan
teaching professor/s: Puzović M. Radovan, Stojadinović M. Slavenko
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: written
parent department: production engineering

goals
The aims of the course are to acquaint students with theoretical and applied knowledge and regularities in the manufacturing processes and metrological systems in production engineering, using systemic approach. This knowledge helps production engineers to manage treatment and metrological processes in the quality management system.

learning outcomes
Upon successful completion of the course Production Technology and Metrology, studenty should be able to: - Make a plan of the experiment to define and experimentally determine the parameters of machinability functions used to describe characteristic phenomena (mechanical, thermodynamic and tribological) in the cutting zone and by plastic deformation. - Apply measuring devices and data acquisition systems to measure forces, moments, temperature and tool wear parameters in the cutting process (turning and drilling). - Optimize the machining process by means of the productivity function. - Recognize the characteristics of the metrology system in the industry. - Choose the metrology system in relation to the metrological task and the required accuracy. - Design a metrology plan to measure and inspection on CMM. - Followed metrological characteristics of the system in utilization. - Carry out techno-economic analysis of the application of CMM in the industry.

theoretical teaching
AN-1: Basic concepts in the theory of metalworking by plastic deformation;

AN-2: Mechanics of orthogonal cutting;

AN-3; Thermodynamics of cutting process and application of coolants and lubricants;

AN-4: Tribology of cutting process;

AN-5: Material machinability and techno-economy;

AN-6: Essential characteristics of measuring systems in production metrology;

AN-7: Sensors;

AN-8: Analog and digital measuring systems;

AN-9: Pneumatic measuring systems;

AN-10: Laser measuring systems and photoelectric measurement systems.

Each theoretical teaching hour is followed by one hour of explanations relevant to teaching contents.

practical teaching
PR-1: Introductory considerations of production technologies;

PL-1: Determination of deformation in treatment by compression;

PL-2: Resistance measurement in treatment by boring/cutting force;

PL-3: Resistance measurement in treatment by chipping;

PL-4: Methods of cutting temperature measurement;

PL-5: Determination of machinability parameters;

PR-2: Introduction to production metrology;

PL-6: Practical application of metrological systems for length and angle tolerances;

PL-7: Practical application of metrological systems for shape and position tolerances;

PL-8: Practical application of metrological systems for tolerances of micro and macro geometry of surface;

PL-9: Legal metrology, standards of length and angle;

PL-10: Industrial metrology/work on NUMM.

prerequisite
Defined by the Study Program Curriculum.

learning resources
[1] Handouts in e-form. /In Serbian/ [2] Instructions for doing laboratory exercises, e-form. /In Serbian/ [3] Monograpy from area of production metrology (in preparation). [4] Site for 1 and 2 contains a list of references in the respective area and links to leading organizations and institutions in this field. [5] Technical resources for the course: Laboratory for Production metrology and TQM as well as ZMA that have necessary equipment and licensed software for doing exercises in this subject.

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
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: 15
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: 40
laboratory exercises: 20
calculation tasks: 0
seminar works: 0
project design: 0

final exam: 30
requirements to take the exam (number of points): 40

references

Handouts in e-form. /In Serbian/
Instructions for doing laboratory exercises, e-form. /In Serbian/
Monograpy from area of production metrology (in preparation)
The site with bibliographical references, books and journals from this area and links to the addresses of leading organizations and important institutions in this field
Technical resources for the course: Laboratory for Production metrology and TQM as well as MTL that have necessary equipment and licensed software for doing exercises in this subject

Shipbuilding Technology

ID: BSc-0917
responsible/holder professor: Kokotović M. Branko
teaching professor/s: Kokotović M. Branko
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: oral
parent department: production engineering

goals
Acquisition of basic knowledge about manufacturing processes, production equipment and organization of work in shipbuilding technology.

Acquisition of basic knowledge about quality control of manufacturing processes in shipyard. Studies of production documentation for processes in ship building.

Studies of computer aided activities in preparation of manufacturing processes. Studies of different risk groups for working safety and health as well as measures for prevention of such risks.

learning outcomes
Upon successful completion of this course students should be able to:

Apply fundamental knowledge about manufacturing system

•Make the right choice of machining system according to required technology for production of parts of the hull structure

•Apply knowledge about quality aspects in ship building process

•Apply experience, built through laboratory exercises, in programming of CNC machines for plate cutting, using CAM software environment

•Apply the logic of building of hull substructures

•Use, in adequate manner, technological documentation specific for ship building technology

•Use various standards and rules of classification societies, related to ship building technology

•Apply knowledge about organization of ship building process

•Apply standards with regulation of working safety in various technological units of shipyard

theoretical teaching
1. Introduction; Shipyard: definition and types

2. Manufacturing processes in shipbuilding technology

3. Steel stockyard; Preparation of plates and profiles

4. Cutting technologies for plate and profile cutting, Processes based on plastic deformation (cold cutting); Thermal cutting processes; Numerically controlled manufacturing systems for cutting and marking

5. Profile and plate bending technology

6. Decomposition of hull in structural members, Pre-assembly of the hull substructures; fabrication of assemblies and sections

7. Methods of welding of hull substructures. Inspection of welded joints and constructions

8. Forming of elements and assemblies of pipelines

9. Handling and transportation equipment
10. Hull assembly
11. Ship launching methods and equipment
12. Planning of ship building; Scheduling
13. Technological documentation in shipyard
14. Computer support in preparation of manufacturing processes in the shipyard
15. Production areas in the shipyard; Shipyard layout – examples
16 Ensuring of working safety

practical teaching
Practical teaching consists of auditorial exercises, laboratory work, and consultations. It embraces the following units:

1. One auditorial exercise: Programming of CNC machines for cutting operations (G-code, CAM software environment, Verification through simulation, Postprocessing)
2. Three laboratory exercises: (1)Production processes in shipbuilding technology (Visiting of shipyard), (2)Operation and programming of CNC machines for cutting of plates and (3)Technology design for cutting operations of 2D contours in CAM software environment Instructions for the work are given for each exercise. Each laboratory exercise assumes completion of the report.
3. Two consultation.

Knowledge check comprises: two colloquiums and final examination.

prerequisite
Study curriculum and student motivation for learning about shipbuilding technology according to the goals set and outcomes offered.

learning resources
1. Susa M.: Shipbuilding technology, FME, Belgrade, 2007. /In serbian/
2. Storch R., Hammon C., Bunch H., and Moore R., Ship Production, 2nd Edition, SNAME New Jersey, USA, 1995.
3. Two computer work places with instalation of CAM software (Nesting, 2D machining, Simulation)
4. One work place with numerically controlled machine tool for verification programmed machining of 2D contour
5. Production plant- Manufacturing processes in shipbuilding technology, "Vahali" Shipyard in Macvanska Mitrovica

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
auditory exercises: 6
laboratory exercises: 22
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 2
discussion and workshop: 0
research: 0

knowledge checks: 15
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

Hocker M.F., Ward A.C., The Philosophy of Shipbuilding, Texas University Press, 2004, USA
Taggart R. (Editor): Ship Design and Construction, The Society of Naval Architects and Marine Engineers, New York, 1980.
Shipbuilding and Repair Quality Standard , IACS Recommendation No. 47, 1996. / Rev.7, 2013.
Shipyard Industry Standards, U.S.Department of Labor, Occupational Safety and Health Administration OSHA2268-03R, 2009.

Tools and Fixtures

ID: BSc-1361
responsible/holder professor: Popović D. Mihajlo
teaching professor/s: Pjević D. Miloš, Popović D. Mihajlo
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: oral
parent department: production engineering

goals
Acquisition of theoretical and practical knowledge of design, computations and constructions of clamping fixtures, sheet-metal processing tools, metal pressure casting tools, forming and shaping plastics tools and forging tools, all this based on modern technologies and optimal solution.

learning outcomes
On successful completion of the course, students should be able to:

• Identify different cutting tools and fixtures to use them in a respective metalworking process by cutting.

• Evaluate each element with respect to differences in positioning, clamping and present accompanying errors.

• Identify different fixture concepts and perform accuracy computations. Students acquire the skill to understand more clearly the concept of metalworking process accuracy.

• Describe in brief the cutting tool and fixture used for manufacturing a specified product.

theoretical teaching
Theory of the principles of work-piece locating and positioning. Theory of the cutting process, determination of the principle machining factors, deformation force and deformation work. Stability theory. Theory of elastoplastic deformation. Determination of the principle machining factors in plastic deformation processing. Construction and computations for elements of clamping fixtures, computations for clamping fixtures accuracy, sheet-metal processing tools, construction characteristics of tool elements, forging tools, metal pressure casting tools, and forming and shaping plastics tools.

practical teaching
Laboratory exercises where students accomplish practically the task of cutting tools and fixtures conception. Of the cutting tools, students are acquainted with the design of turning tool, drill, counter-bore, reamer, tap, milling cutter, wheel, as well as with engineering materials used to make cutting tools. Of the clamping fixtures, students are familiarized with three-jaw chuck, rotating center, rest, lathe dog, wedge-lock vise, expansion collets, as well as with the design of universal, special and universal jig and fixture system. Design project for a concrete task related to engineering practice.

prerequisite
Defined by the Study Program Curriculum.

learning resources
1. Universal fixtures, Special clamping fixtures and Aggregated clamping fixtures, Lab for FTS, metal working and tools, ЛПС [In Serbian]

2. Cutting tools, sheet-metal processing tools and forging tools, Lab for FTS, metal working and tools, ЛПС [In Serbian]

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
auditory exercises: 0
laboratory exercises: 14
calculation tasks: 0
seminar works: 0
project design: 14
consultations: 2
discussion and workshop: 0
research: 0

knowledge checks: 15
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): 40

references

Tanović Lj., Jovičić M., TOOLS AND FIXTURES – design, computations and constructions of clamping fixtures, FME, Belgrade, 2011, КПН [In Serbian]
Jovičić M, Tanović Lj., TOOLS AND FIXTURES – computations and construction of tools for building a sheet metal part, FME, Belgrade, 2007, КПН [In Serbian]

RAILWAY MECHANICAL ENGINEERING

- Fundamentals of Rail Vehicles
- Life Cycle of Railway Vehicles
- Railway Systems
- Theory of Traction

Fundamentals of Rail Vehicles

ID: BSc-1030
responsible/holder professor: Milković D. Dragan
teaching professor/s: Milković D. Dragan
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: oral
parent department: railway mechanical engineering

goals
1. Understanding the basic rail vehicles assemblies,

2. Acquiring the knowledge needed for understanding of functioning of the basic structural assemblies,

3. Training for the application of acquired knowledge for solving practical engineering problems, especially in the field of maintenance of the railway vehicles.

learning outcomes
After completing the course, students should be able to:

1. Explain the functional and structural differences between basic types of rolling stock.

2. Explain the tasks and functioning of the main assemblies of the rail vehicles.

3. Identify actions required to resolve typical failures in operation and in the maintenance of the rail vehicles.

4. Apply appropriate regulations and standards in the design and maintenance of the railway vehicles.

5. Apply basic computer tools for construction and calculation of the simple assemblies of the rail vehicles.

theoretical teaching
The fundamental structural assemblies and the main design parameters of the rail vehicles. Regulations for design, operation and maintenance of the railway vehicles. One axle running gear. Typical bogie types for freight wagons and passenger coaches. Suspension system. Carbody - bearing structure. Review of the regulations concerning strength of the carbody and bogie structures. Draw-buff gear: fundamental characteristics, main types. Vehicle gauge. Fundamental criteria of the dynamic behavior of the rail vehicles. Fundamental design concepts and functioning principles of the rail vehicle brakes.

practical teaching
Summary of the design variants of different types of rail vehicles. Examples of selection and limitations of the basic vehicles parameters. Marking of the rail vehicles. The examples and analysis of the regulation excerpts. Load analysis of the wheelsets. Inspection of the wheelsets. Load analysis of the bogie frame. Load analysis of the carbody. Examples of strength calculations. Design variants of the elastic suspension systems. The fundamental parameters of the elastic suspension system and boundary conditions for their selection and calculation. Types of draw-buff gear. Main characteristics of draw-buff gear and their testing. Review of the brake system on the train and on the single vehicle. Inspection of the basic parameters of the new brakes, after repair and in daily operation.

prerequisite
Enrolled the third year and desirably completed: Mechanics 1, 2 and 3, The base of the strength of constructions and Machine elements 1 and 2.

learning resources

- G. Simic, Fundamentals of rail vehicles, hand-out
- G. Simic, Instructions for writing student papers, hand-out
- G. Simic, Railway vehicles, Design and calculations, Faculty of Mechanical Engineering, 2013.
- Appropriate regulations and standards

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
auditory exercises: 11
laboratory exercises: 0
calculation tasks: 7
seminar works: 3
project design: 0
consultations: 4
discussion and workshop: 5
research: 0

knowledge checks: 15
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: 15
seminar works: 5
project design: 0
final exam: 50
requirements to take the exam (number of points): 25

references

G. Simic, Railway vehicles, Design and calculations, Faculty of Mechanical Engineering, Belgrade 2013.

Life Cycle of Railway Vehicles

ID: BSc-1389
responsible/holder professor: Tanasković D. Jovan
teaching professor/s: Lučanin J. Vojkan, Tanasković D. Jovan
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: oral
parent department: railway mechanical engineering

goals
1.Introduction to basic concepts important for understanding the life cycle of railway vehicles

2.Acquiring knowledge necessary to understand the issues of the life cycle of railway vehicles

3.Training for the application of acquired knowledge in solving practical problems in the design, use and maintenance of railway vehicles

learning outcomes
After successfully finishing of course students would be able to:

- define phases of the life cycle of railway vehicles;

- briefly describe each phase of the life cycle of railway vehicles;

- compare different approaches of realizations of design project and production of railway vehicles;

- prepare a detailed timeline of the project realization with exactly defined activities;

- differ reliability, availability and functional suitability of technical systems;

- discuss about possible ways of raising system reliability.

theoretical teaching
Theoretical classes (Definition of rail vehicles and systems as required,Design and production,Use and maintenance,Concept of system effectiveness,Theoretical basis of reliability,Methods of determining the reliability,Prediction of reliability, Allocation of reliability,Failure analysis.System maintenance,The concept of maintenance,Maintenance technologies,Information systems in maintaining,Phase conception - the mission profile and scenario,feasibility studies,operational and maintenance concepts,factors of effectiveness of work and support,criteria for protection and logistical planning,Preliminary phase of development,Preparation of detailed project,Prediction and analysis of technical support,Review of construction,Testing and evaluation,Feedback and corrective action.Production, installation, testing, control and distribution devices.Implementation and data collection on elements of technical support,Use and maintain in the exploitation conditions.Testing process.Capability rating of technical support.Feedback and corrective action,Standards of the International Union of Railways,National standards IEC-EN,Regulations of the national railways in the area of operation and maintenance,Workshops for the maintenance of railway vehicles,General settings of maintenance technology,Technology in railway vehicles maintenance.

practical teaching
Practical learning, auditory exercises, assignments, presentation of practical examples in the field of designing, production, use and maintenance. Discussion and workshops.

prerequisite
Attended and passed the courseЧ Mechanics 1 and Engineering Graphics.

learning resources
Syllabus, Guidebook for solving the tasks, Handouts, Internet resources, articles

number of hours: 75

active teaching (theoretical): 20
lectures: 20
elaboration and examples (revision): 0

active teaching (practical): 40
auditory exercises: 28
laboratory exercises: 0
calculation tasks: 2
seminar works: 0
project design: 0
consultations: 5
discussion and workshop: 5
research: 0

knowledge checks: 15
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: 25
laboratory exercises: 0
calculation tasks: 20
seminar works: 0
project design: 0
final exam: 45
requirements to take the exam (number of points): 35

references

Nikola Vujanovic, Theory of reliability of technical systems, Belgrade, 1990.
Jovan Tanaskovic, Aleksandra Kostic, Life Cycle of Railway Vehicles, Handout, 2020.

Railway Systems

ID: BSc-0960
responsible/holder professor: Tanasković D. Jovan
teaching professor/s: Lučanin J. Vojkan, Tanasković D. Jovan
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: oral
parent department: railway mechanical engineering

goals
1. Introducing students with railway transport system.

2. Introducing students with concept, characteristics, drive systems of railway vehicles and their interaction with railway infrastructure.

3. Introducing students with systems of passive safety of rail vehicles.

learning outcomes
After successfully finishing of course students would be able to:

- define role, advantages and disadvantages of railway transport;

- differ types and basic characteristics of railway vehicles;

- briefly describe characteristics of railway vehicles and their interaction with the railways infrastructure;

- define and compare role of active and passive safety of railway vehicles;

- recognize basic infrastructure elements and define their role and main characteristics;

- describe and differ phases of life cycle of railway vehicles.

theoretical teaching
The role and importance of railway transport. Characteristics of railway transport. Development during history. Types of railway vehicles, structure of the vehicles and characteristics. Dynamic characteristics of vehicles, conception, traction characteristics, train resistances and traction effort.

Subsystems of vehicle:

1. Achieving traction force of vehicles, applied of technics and technologies, adhesion and wear;

2. Energy supply, traction system and brake system;

3. Bogies;

4. Passive Safety of Rail Vehicles

5. Infrastructure, elements and characteristics;

6. Freight and passenger traffic, interoperability, management and planning;

7. Elements of reliability, availability, maintenance and safety, life-cycle costs of rail vehicles.

practical teaching
Practical teaching is done through exercises with aim to introduce students with practical solutions which are applied in railway.

Visits to producers of railway vehicles and components are the primary way of introducing students with railway engineering. On this way, students get insight in production technology and specifics which characterizes this production.

Also, visits the national railway operators with aim to provide direct access to the various systems and technologies are a part of practical exercises: planning and monitoring of traffic, energy supply, infrastructure facilities, and maintenance of railway vehicle.

prerequisite
Students enrolled in the second year of study.

learning resources
Scripts, computer and associated equipment. Professional journals and prospects.

Availability resources of national railway operators and Rolling Stock Company.

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 35
auditory exercises: 20
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
consultations: 5
discussion and workshop: 10
research: 0

knowledge checks: 10
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: 0
final exam: 4

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): 30

references
Танасковић Ј., Лучанин В., Railway Systems, script, 2015.
Coenraad Esveld, MODERN RAILWAY TRACK, Second Edition, Delft University of Technology, MRT-Productions, 2001.
Brenna M., Foiadelli F., Zaninelli D., Electrical Railway Transportation Systems, IEEE PRESS, Wiley, 2018.

Theory of Traction

ID: BSc-1185
responsible/holder professor: Tanasković D. Jovan
teaching professor/s: Lučanin J. Vojkan, Tanasković D. Jovan
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
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
After successfully finishing of course students would be able to:

- differ basic characteristics of tractive vehicles;

- briefly describe the role and way of functioning of the power transmission and their components;

- recognize basic types of couplings and compare their characteristics;

- describe and differ train resistance;

- calculate of the train resistance and tractive effort;

- recognize importance of application of regulations and standards in the field of railway traction.

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
Attended and passed the course Mechanics 1.

learning resources
Literature that is available in the Faculty Bookstore and Library; Handouts available on lectures; Internet resources (KOBSON).

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
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: 15
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: 20
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.
Brenna M., Foiadelli F., Zaninelli D., Electrical Railway Transportation Systems, IEEE PRESS, Wiley, 2018.

STRENGTH OF STRUCTURES

Fundamentals of strength of structures

Strength of materials

Fundamentals of strength of structures

ID: BSc-1193
responsible/holder professor: Milovančević Đ. Milorad
teaching professor/s: Anđelić M. Nina, Balać M. Igor, Buljak V. Vladimir, Milovančević Đ. Milorad, Milošević-Mitić O. Vesna, Petrović S. Ana
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: written+oral
parent department: strength of structures

goals
The aim of this course is to introduce students to some complex loadings. The bending of the statically indeterminate beams, as well as torsion and buckling of an arbitrary cross sections are considering. Course shows the method of determining the equivalent stresses in a complex spatial loading of structures, that students later can use the computer programs based on Finite Element Method-FEM.

learning outcomes
Mastering the program contemplated by this course, students acquire next skills: mastering of methods, procedures and processes of research in this field; application the knowledge in this practice; thorough knowledge and understanding of the discipline; solving practical problems using scientific and technical methods and procedures; the possibility of the proper use of computer programs based on Finite Element Method-FEM.

theoretical teaching
The stability of compressed baems- buckling. Statically indeterminate beams. Decomposition method. Deformation energy: the concept, a general term, additional work. Theorem of reciprocity. Kastigliano's theorems. Maxwell-Mohre integrals and Verescagin's procedure. Statically indeterminate problems. Canonical equation. Force method. Symmetric planar structures. Analysis of stress and strain. Volumetric strain. Hypotheses about the fracture of the material. Calculation of the stucture complex stress. Bending in two plains: the concept, stress, strain. Shear center. Excentric force load. Displacement method: introduction, setting. Basis of the FEM. Methods of defining the problem. Types of finite elements.

practical teaching
The tasks of buckling. Examples of statically indeterminate beams. Determination of displacements for staticaly determinated plane beam-constructions on bending load. Application of deformation energy and Castigliano's theorem. Application of the force method for the solution of statically indeterminate problems (external static indefinite beams, symmetrical and closed structures). Calculation of torsional characteristics of various cross-sections. Application of the hypothesis: general considerations, the maximal normal stress, the maximal shear stress and the maximal specific deformation energy of the shape changes. Complex loads constructions - circular and prismatic cross-section, thin-walled cross-sections, standard sections. Examples of displacement method. Consultations and individual work tasks. Laboratory exercise.

prerequisite
The condition is defined by the curriculum program of the study.

learning resources
1.Tables of Strength of Materials: D. Ruzic, R. Cukic, M. Dunjić, M. Milovančević, N. Andjelic, V. Milosevic Mitic

2.Handouts from the site of the Department

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
auditory exercises: 20
laboratory exercises: 5
calculation tasks: 2
seminar works: 0
project design: 0
consultations: 3
discussion and workshop: 0
research: 0

knowledge checks: 15
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: 5
calculation tasks: 5
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

Strength of materials

ID: BSc-1192
responsible/holder professor: Anđelić M. Nina
teaching professor/s: Anđelić M. Nina, Balać M. Igor, Buljak V. Vladimir, Milovančević Đ. Milorad, Milošević-Mitić O. Vesna, Petrović S. Ana
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 4
final exam: written+oral
parent department: strength of structures

goals
The aim of this course is to introduce students to the concepts of stress and strain, the relevant materal properties and geometric characteristics of the cross sections. The core of this matter relates to the determination of stress and strain of an elementary loading types (axial loading, torsion, bending). The special attention is in the interpretation of the physicality of the problem, too.

learning outcomes
By mastering the curriculum, the students receive the following skills: mastery of methods, procedures and processes of research; in-depth knowledge and understanding the concept of the strength theory; solving practical problems using scientific methods and procedures; linking basic knowledges from various fields with the aim of making it usable in practice and in various computer programs.

theoretical teaching
Theoretical instruction. Introduction. The connection between strength and deformation. The shape of the body. Geometrical properties of the cross-sections. The principal moments of inertia and the ellipse of inertia. Types of forces. The concept of stress and strain. Equilibrium conditions in the cross-section. Axial loading: terms of balance, the impact of temperature, the ideal shape. The concept of static indeterminacy. Force method. Analysis of stress and dilatation in staff cross-section. Conjugate stresses. Plane stress state. Shear. Torsion: terms of balance, angle of torsion, shear stress and dimensioning, the ideal shape, static indefinite problems. Bending: introduction, pure bending: terms of balance, resistance moment, normal stress; bending forces: shear stress, the ideal form of curved beams, standard sections; bending deformation.

practical teaching
Practical instruction: tasks relating to the calculation of geometrical characteristics of the cross-sections (moment of inertia); the calculation of stress and strain in primary loading of structural elements: axial loading (the effect of mechanical forces and temperature, normal stress, static notion of uncertainty, the plan shifts), torsion (shear stress, angle of torsion, dimensioning by the allowed stress and allowable angle), pure bending and bending by forces (distribution of normal stresses and shear stresses in the cross section beams, standard sections, deformation of beams with overhangs and joints). Consultation and individual work tasks in these fields.

prerequisite
The condition is defined by the curriculum program of the study.

learning resources
1. Strength of Materials: Milorad Milovančević, Nina Anđelić (tutorial);

2. Tables from the strength of materials: M. Milovančević, N. Andjelic, V. Milosevic Mitic, M. Dunjić, D. Ružić, R.Čukić;

3. Handouts from the site of the Department of Strength of constructions;

number of hours: 45

active teaching (theoretical): 18
lectures: 12
elaboration and examples (revision): 6

active teaching (practical): 18
auditory exercises: 14
laboratory exercises: 0
calculation tasks: 2
seminar works: 0
project design: 0
consultations: 2
discussion and workshop: 0
research: 0

knowledge checks: 9
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: 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): 15

references

M. Milovančević, N. Anđelić: ''Strength of Materials'' (in Serbian), University of Belgrade, Faculty of Mechanical Engineering, Belgrade, 2015.
M. Milovančević, N. Andjelic, V. Milošević-Mitic, M. Dunjić, D. Ružić, R.Čukić: Strength of materials-Tables, University of Belgrade, Faculty of Mechanical Engineering, Belgrade, 2015.

THEORY OF MACHANISMS AND MACHINES

Aesthetic Design

Basic technological operations in food industry

CONSTRUCTIVE GEOMETRY AND GRAPHICS

Engineering Graphics

Hydraulic and pneumatic mechanisms and installations

Mechanisms Design

Aesthetic Design

ID: BSc-0988
responsible/holder professor: Jeli V. Zorana
teaching professor/s: Jeli V. Zorana, Popkonstantinović D. Branislav, Stojićević D. Miša
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: seminar works
parent department: theory of machanisms and machines

goals
Introducing students to the standards and principles of aesthetics in the design process; recognition of subjective and objective factors forming aesthetic judgment; processing aesthetic elements and principles; the study of geometric legality compliance; use of classic and modern means for creating aesthetic properties; getting to know the characteristics of modern graphic language and aesthetic properties of packaging and advertising.

learning outcomes
The student has gained the ability to aesthetic evaluation and the formation of aesthetic judgment; through theoretical and practical classes the student is trained to creatively used to abstract elements and principles of aesthetics and practical (classical and modern) means for creating aesthetic qualities of form.

theoretical teaching
Definition Aesthetics and name etymology; term factors and the importance of aesthetic judgment and aesthetic criteria; aesthetics as a factor of visual communication; detailed analysis of the aesthetic design elements form; processing and analysis of basic aesthetic principles-Design forms; processing of geometric principles as essential factors of aesthetics and visual communication; term compliance compositions; methods for creating and presenting aesthetic characteristics (classic and contemporary); sketching and drawing; basic patterns of angled projection, orthogonal axonometry, central projection and perspective; principles of computer modeling shapes using appropriate CAD software concept of modern graphic characters; the role of graphic characters in the context of contemporary visual communication; aesthetics characters, symbols and meanings; aesthetic properties of packaging and packaging products; advertising and product presentation.

practical teaching
Independent analysis, creation and presentation of examples on the subject of universal attitudes toward aesthetics and the basic principles of induction aesthetic values and aesthetic evaluation; exercises use aesthetic elements and principles; constructive processing classic geometric legality of aesthetics; classes of classic and modern means of creating and presenting aesthetic qualities of the product; exercises in creating characters with an emphasis on aesthetically-visual meaning.

prerequisite
Passed exams Constructive Geometry and Graphics and Engineering Graphics.

learning resources
Notes: The aesthetics of the product; author: Branislav Popkonstantinović;

Necessary additional materials (handouts, setting tasks, seminar papers, etc.) are given on the website or reproduced on paper.

Electronic materials larger volume of students may be available in immediate contact. Teaching is realized by combining the video display and table.

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
auditory exercises: 5
laboratory exercises: 6
calculation tasks: 5
seminar works: 7
project design: 0
consultations: 3
discussion and workshop: 3
research: 1

knowledge checks: 15
check and assessment of calculation tasks: 0
check and assessment of lab reports: 2
check and assessment of seminar works: 5
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: 0
test/colloquium: 30
laboratory exercises: 5
calculation tasks: 5
seminar works: 30
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

The Aesthetics of Visual Communication; author: Branislav Popkonstantinović, Novi Sad, 2013.
Drawing for Designers, Alan Pipes, Laurence King Publishing, 2007.
Design, Tomass Hauffe, DuMont Buchverlang, 2011.

Basic technological operations in food industry

ID: BSc-1252
responsible/holder professor: Stojićević D. Miša
teaching professor/s: Veg A. Emil, Jeli V. Zorana, Popkonstantinović D. Branislav, Stojićević D. Miša, Šiniković B. Goran
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: written
parent department: theory of machanisms and machines

goals
1. Acquiring basic knowledge of the physical, chemical and biological changes in materials processed during the technological process in the food industry.

2. Getting acquainted with the basic concepts necessary for dealing with matter in the field of food technology and food science.

3. Division of basic technological operations that are encountered in the food industry, primarily in the mill-bakery-confectionery, dairy, slaughterhouse and butchery and vegetable-growing industry.

4. Means of food engineering in food technology.

learning outcomes
1. Analysis of existing solutions and their effects

2. Adoption of practical knowledge

3. Application of knowledge in practice

4. Understanding and basics of the problems of the process in the food industry

5. Resolving the cases of food processes

6. Linking knowledge from different areas and their application

7. Monitoring and application news in the profession.

theoretical teaching
Introduction to the food processing, mechanical operations. Knowing of the basics of technological processes in food engineering: processing of flour, milk and dairy products, fruits and vegetables and meat processing. Classification of basic technological operations in the production of food products. Mechanical operations: grinding, crushing, grinding, chopping, peeling, sowing, mixing, ironing, lamination, pressing, melting, filtering, centrifuging, deposition, dosing, dosing, spraying, extruding, sorting, calibrating. Types of blends. Power required for mixing. Optimum number of rotations when mixing. Pressure into the production of cheese and cheese. Pressing-washing of fruits and vegetables. Thermal operations in the production of food products. Overview of basic thermal operations in the production of food products: baking, frying, drying, smoking. Drying stages. The effects of various factors on thermal. Heat exchange, cooling. Heating and cooling of the liquid in the vessel. Sources of heat and methods of heating. Capacitors. Calculation of the capacitor. Natural and artificial cooling. Refrigeration. Compressors. Scheme of compressor cooling system. Other operations in food engineering. Internal transport: pneumatic, hydraulic and mechanical. Bands, inspection, worm, chain transport. Transport cans. Bottle transport of bottles. Pipelines and fittings. Selection of tube and fittings pipes for use in food injection. Pipes made of gray cast, steel cast, carbon steel, galvanized pipes, stainless steel tubes, copper pipes, glass tubes, plastic pipes and the like. Compensators. Lire. Seals. Heat insulation, heating, defrosting and pipe marking. Regulation and measurement of fluid flow. Valves. Lockers. Taps. Electromegnets. Placing the pipe

practical teaching
First laboratory exercise: going to the plant dealing with mechanical operations in the food processing industry, monitoring of mechanical operations, report. Second laboratory Exercise: Start-up in which thermal operations are performed in the production of food products, monitoring operations and writing reports. Third laboratory exercise: visits to food processing plants, analysis and transcription of the transcript, writing reports. Preparation of a project which includes the definition of the project task, the necessary calculations and the drafting of the complete technological process of the finished food product. Consultations: consideration of completed active teaching and students' questions.

prerequisite
Passed Engineering Graphics and Constructive Geometry and Graphics.

learning resources
Script in preparation, Z. Jeli. In order to successfully overcame the subject, it is necessary to use the instructions for creating projects, handouts, Internet resources and videos.

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
auditory exercises: 2
laboratory exercises: 6
calculation tasks: 4
seminar works: 0
project design: 15
consultations: 3
discussion and workshop: 0
research: 0

knowledge checks: 15
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: 2
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: 15
calculation tasks: 0
seminar works: 0
project design: 25
final exam: 30
requirements to take the exam (number of points): 42

references

CONSTRUCTIVE GEOMETRY AND GRAPHICS

ID: BSc-0203
responsible/holder professor: Popkonstantinović D. Branislav
teaching professor/s: Veg A. Emil, Jeli V. Zorana, Popkonstantinović D. Branislav, Stojićević D. Miša, Šiniković B. Goran
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 2
final exam: written
parent department: theory of machanisms and machines

goals
The objectives of this course are to acquire knowledge for comprehending, constructive processing and modeling of the objects of three-dimensional space. Practicing and mastering the basic operations and methods for efficient geometric analysis and synthesis of various abstract and concrete forms can be considered as the study program objective. Moreover, particularly important goal of this course is the theoretical preparation and development of creative skills for effective use of modern software packages for three-dimensional modeling and design.

learning outcomes
Mastering the program, students obtain and improve ability to use geometric operations and methods for creative observation and modeling of three-dimensional space. In addition, the adoption of the scheduled curriculum, a student acquires the knowledge and skills for effective visual communication in engineering practice.

theoretical teaching
Theoretical course includes:

1) Learning the principles of the Constructive geometry and graphics (CGG), introducing the concepts of projection, orthogonal projections, coordinate systems and spatial coordinates, defining elements, relations, and CGG postulates; explanation of the basic CGG methods;

2) Application of the CGG methods; treatment of classical positional and metric problems;

3) The constructive geometrical analysis and treating of a plane in arbitrary position; the plane revolution, the oblique plane figures;

4) The constructive geometrical analysis and treating of an objects on an incline plane, the spatial positional and metric problems;

5) The polyhedron truncation (truncation of pyramids and prisms), learning the basic principles and constructive geometrical methods of developing surfaces (the net); building the concrete models of truncated prisms and pyramids;

practical teaching
Practical lectures are conducted through a cycle of exercise consisting of 6 auditory and 6 independent individual exercises. Auditory exercises students accomplish in college with the help of assistants, and independent practice through homework. The exercises are performed with the following contents:

1. The orthogonal projections delineation, training the use of spatial coordinates, three-dimensional coordinate system and the main issues and postulates of CGG;

2. Practising the basic methods of CGG (transformation and revolution)

3. Application of CGG methods (the measure of lengths, angles, area); practicing the classical positional and metric problems;

4. The constructive geometrical analysis and treating of a plane in arbitrary position, practicing the procedures of geometric plane revolution and modeling of geometrical figures on an oblique plane;

5. Spatial positional and metric problems; constructive analysis and synthesis of geometrical objects on an incline plane;

6. Truncation of pyramids and prisms; practicing the methods and procedures of surface developing (the net) and modeling of a truncated pyramids and prisms;

prerequisite
The course of Constructive geometry and graphics is mandatory for all students.

learning resources
1. Tutorial: CONSTRUCTIVE GEOMETRY AND GRAPHICS; authors: Dr. Aleksandar Veg, Miodrag Stoimenov, Ljubomir Miladinovic, Branislav Popkonstantinović; Faculty of Mechanical Engineering, Belgrade 2005.

2. Handbook for practice: A constructive geometry in the graphics - PRACTICUM; authors: Dr. Branislav Popkonstantinović, Mr. Zoran ate, Mr. Rasa Andrejevic, Goran Šiniković; Faculty of Mechanical Engineering, Belgrade 2010. Note: The textbook and handbook are available in printed form.

number of hours: 30

active teaching (theoretical): 11
lectures: 8
elaboration and examples (revision): 3

active teaching (practical): 11
auditory exercises: 5
laboratory exercises: 0
calculation tasks: 6
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks: 8
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: 1
test, with assessment: 0
final exam: 2

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

Engineering Graphics

ID: BSc-1251
responsible/holder professor: Popkonstantinović D. Branislav
teaching professor/s: Veg A. Emil, Jeli V. Zorana, Popkonstantinović D. Branislav, Stojićević D. Miša, Šiniković B. Goran
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: written
parent department: theory of machanisms and machines

goals
The goal of the course is that students master the skills necessary for successful viewing (and reading) of machine parts components technical drawings. The student should know all the rules and standards that are used for formating, dimensioning and defineing of the machine parts machining on the drawings.

learning outcomes
The outcome of this course is the students' ability to model mechanical parts as well as their assemblies by the using of the software package SolidWorks. Moreower, it is necessary to show the assemblies and parts on drawings with the appropriate sections so that they can be fully formally, dimension and machining defined.

theoretical teaching
Drawing in Mechanical Engineering; displaying objects in the drawing; composition parts, pictures of objects. Axonometric projection of objects and their interpretation. Views; basic views; separate views; types of lines in mechanical engineering. Sections, a complete crosssection; half cross-section, partial cross-section, labeling section; profile sections. Breakthroughs; symmetrical parts, repeated details. Dimensioning; function wheel; elements of Dimensioning; marking point on the drawing; methods quotation. Threads display; coil; threaded double and tags for loops. Marking sheet surface; surface roughness; means for quality of workmanship, labeling on the drawings. Technical Letter; scale, the formats, headers and components; positional label elements. Gear display; Springs display; Welded seams display. Shape and position tolerances.

practical teaching
Axonometric sketching and 3D modeling of simple machine part, displaying the same model in three main views. Presentation of machine parts by imaginary sections in three major orthogonal views. Preparation 3D model of a given machine part; making technical drawings in sufficient numbers of views using the imaginary section; the using of special views and sections; dimensioning part of the drawing. Molding of all parts of the given assemblies; creating the production drawings in sufficient number of views with appropriate labeling and providing a measure of dimensions, making components, filling tables in the drawing, drafting workshop drawings for at least three part of the circuit which are connected together; numbering workshop drawings in accordance with the numbering of the assembly. Creating 3D model for three possible models for the (complex) mechanical parts, development of appropriate technical drawings in a sufficient number of views, using reflective section; application of particular views and cross sections; dimensioning; indication the quality of roughness. All exercise assignments are done either directly, bu the using of drawing tools or by the using of suitable and appropriate software applications, such as SolidWorks is.

prerequisite
No condition.

learning resources
D. Petrović, S.Đorđević, M. Stoimenov, Lj. Miladinović: ENGINEERING GRAPHICS,

S.Đorđević, D.Petrović: ENGINEERING GRAPHICS -Practicum for exercises-

number of hours: 75

active teaching (theoretical): 30
lectures: 25
elaboration and examples (revision): 5

active teaching (practical): 30
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: 15
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: 5
test/colloquium: 40
laboratory exercises: 25
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 20

references

Hydraulic and pneumatic mechanisms and installations

ID: BSc-1316
responsible/holder professor: Veg A. Emil
teaching professor/s: Veg A. Emil
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: written
parent department: theory of machanisms and machines

goals
Acquisition of all necessary knowledge for the production and calculation of pneumatic and hydraulic installations. Display all symbols for both areas. The use of hydraulic and pneumatic components as drives of modern machines in various fields of technology. Use of pneumatics as a factory energy source. Regulations and standards for the manufacture of central pneumatic distribution.

learning outcomes
At the end of this course the student should be able to interpret pneumatic and hydraulic diagrams. Should be capable of designing pneumatic mechanisms and electro-pneumatic systems for synchronizing the work of machines. It should also be able to design hydraulic mechanisms, ie. machine and apparatus propulsion systems.

theoretical teaching
Introduction to hydraulic and pneumatic systems, Operation and different concepts of hydraulic and pneumatic cylinders - Construction of pneumatic cylinder as basic components of pneumatic mechanisms, Pneumatic and hydraulic distributors - Overview of construction and operation of pneumatic and hydraulic distributors as control components of cylinders, accessories, Standard cylinder speed control, Symbols in hydraulics and pneumatics, Proportional technology - proportional flow and pressure valves, Vacuum technology - various ways of vacuum production: using vacuum pumps, ejector devices, Calculations in hydraulic and pneumatic mechanisms and installations, Examples and pneumatic mechanisms and installations.

practical teaching
Introduction to models of different pneumatic cylinders, Introduction to models of different hydraulic cylinders, Connection of simple installation with one cylinder and one distributor, Importance of air preparation, Consequences of poor air preparation, Introduction to different configurations of preparation groups, Hydraulic and pneumatic fittings, scheme, Positioning of a pneumatic cylinder with the help of a proportional flow valve, Calculation of air consumption, Preparation of a semestral project

prerequisite
Unconditioned.

learning resources
Software packages for the development and calculation of hydraulic and pneumatic schemes. Software package for simulation of hydraulic and pneumatic mechanisms. The textbook is in preparation. Handout.

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
auditory exercises: 0
laboratory exercises: 15

calculation tasks: 0
seminar works: 9
project design: 0
consultations: 6
discussion and workshop: 0
research: 0

knowledge checks: 15
check and assessment of calculation tasks: 0
check and assessment of lab reports: 4
check and assessment of seminar works: 4
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: 25
calculation tasks: 0
seminar works: 20
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

Mechanisms Design

ID: BSc-1109
responsible/holder professor: Popkonstantinović D. Branislav
teaching professor/s: Popkonstantinović D. Branislav, Stojićević D. Miša
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: written
parent department: theory of machanisms and machines

goals
acquiring the necessary knowledge and developing creative abilities for designing and constructing mechanisms within machines and devices. Mastering some of the software programs for concrete construction of mechanisms (machines and devices), or analyzing their work in order to eliminate the observed shortcomings.

learning outcomes
By mastering the study program, student acquires the following subject-specific abilities: understanding the problems from the theory of mechanisms and machines; solving concrete problems using scientific methods and using adequate software.

theoretical teaching
Introduction to the theory of mechanisms, mechanism structure, kinematic member, kinematic pair, kinematic chain, number of degrees of freedom of movement; The basic mechanism, the synthesis of a complex mechanism, the Assur group; Conditions of Grashof, flat and spatial mechanisms; Kinematics mechanisms, instant centers of rotation, kinematic pair speeds, angular speeds of kinematic members. Acceleration of kinematical pairs, angular acceleration of kinematic members; Dynamics of mechanisms, external and inertial forces and moments in the mechanism; The driving force (moment), the Zhukovsky theorem, the forces (pressures) in kinematic pairs; About synthesis of mechanisms, optimal synthesis of mechanisms in MATLAB; Optimal parametric synthesis of mechanisms, target function; Limits and penalties within the objective function; Real mechanisms, friction and angles of friction in kinematic pairs.

practical teaching
Structure oф mechanisms, kinematic member, kinematic pair, kinematic chain; Obtaining the skills on Solidworks, modeling a member, modeling a kinematics pair; Modeling the kinematic chain, selecting and adjusting the drive; Adjusting the accuracy of the mechanism, reading the position of the kinematic pair or member; Reading current speeds of kinematic pairs and angular speed members, forming a speed diagram in the cycle of the mechanism; Reading the acceleration of the kinematic pair and the angular acceleration of the member, forming an acceleration diagram; Inserting external forces and moments into the mechanism, adjusting the drive mode; Introduction and adjustment of coefficient and radius of friction in kinematic pair, reading of force in kinematic pairs, formation of force diagram in cycle; MATLAB, writing one part of the synthesis program in MATLAB; Parametric optimal synthesis of the mechanism for a given path (MATLAB); Construction by the synthesis of the obtained mechanism in Solidworks.

prerequisite
Not specified.

learning resources
Available only on Serbian.

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
auditory exercises: 0
laboratory exercises: 10
calculation tasks: 20
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks: 15
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: 15
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: 30
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 50

references

THERMAL POWER ENGINEERING

Introduction to Energetics

Introduction to Energetics

ID: BSc-0406
responsible/holder professor: Stevanović D. Vladimir
teaching professor/s: Bajc S. Tamara, Ilić B. Dejan, Milivojević S. Sanja, Petrović V. Milan, Stevanović D. Vladimir, Todorović N. Maja
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: written
parent department: thermal power engineering

goals
The aim is to obtain academic knowledge about the processes and equipment for exploitation of fossil fuels' primary energy, hydropower, nuclear power, geothermal, solar and wind energy, conversion and transformation of primary into secondary energy forms, such as heat, mechanical work, electricity, transport as well as distribution of energy and working fluid, energy storage, and utilization of energy in final consumption for heating, air conditioning and refrigeration.

learning outcomes
Students acquire basic knowledge of technological systems, energy equipment and processes in thermal power plants, hydro power plants, boiler plants, nuclear power plants and heating systems, refrigeration and air conditioning systems. Students become familiar with the processes and technical solutions of turbomachinery, such as water turbines, steam and gas turbines, pumps, fans and compressors, as well as advanced methods and solutions for efficient energy consumption, environmental protection and analysis of macroenergy system.

theoretical teaching
Macroenergy systems and energy flows. Energy, economic and technological indicators of the energy system. Energy of fluid flow, the basic operating principles of turbomachinery, a classification according to the direction of energy transfer, the type of fluid. Pumps and pumping stations. Hydroenergy plants and hydraulic machines. The basic operating principles of steam turbines and their application. The basic operating principles of gas turbines and their application. Thermal power plants and the outline of the main and auxiliary technological systems. Heat and electricity co-generation. Environmental protection in thermoenergetics. Boiler plants, boilers and appliances. Application of boilers. Appliances and furnaces for burning solid (coal, biomass, urban waste), liquid and gaseous fuels. Machines for cooling/refrigeration, natural and artificial cooling. The processes and equipment for obtaining low temperatures. Systems for heating, ventilation, air conditioning and hot water. The energy efficiency in heating and air conditioning. New and renewable energy sources.

practical teaching
Energy consumption in the World and in Serbia. Examples of development of pumps, fans and water turbines. Demonstration of pumps with corresponding fittings in laboratory installation. Hydroelectric power plants. Heat and technological schemes, the basic systems and components of steam power plants. Gas turbines application in energetics and transport. Examples of combined cycle power plants. The calculation of fuel consumption and thermal power plants' efficiency. Emissions of exhaust gasses and environmental protection in thermoenergetics. A visit to a thermal power plant or a laboratory. Chronological development of steam boilers. Classification of heat boilers according to heat carrier (hot water, pressurized water and steam). Basic components of the boiler. Applications of refrigerant equipment and heat pumps. Energy consumption for heating of flats in Belgrade. Calculation of annual energy consumption for heating of various types of housing and different levels of thermal insulation. Examples of energy efficiency in the field of air conditioning, heating and refrigerant systems in the World and in Serbia.

prerequisite
It is advisable to have passed the following exams: Mathematics 1 and Physics and measurements.

learning resources
Course handouts.

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
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: 15
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: 70
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
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.
Woodruff, E., B., Lammers, H.B., Lammers, T.F., Steam Plant Operation, McGraw-Hill, 1998.
Eastop, T.D., Croft, D.R., Energy Efficiency, Longman Scientific & Technical, Harlow, 1990.

THERMAL SCIENCE ENGINEERING

Heating technique fundamentals

Heating technique fundamentals

ID: BSc-1178
responsible/holder professor: Bajc S. Tamara
teaching professor/s: Bajc S. Tamara, Todorović N. Maja
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: written+oral
parent department: thermal science engineering

goals
Acquiring knowledge and skills in the field of heating technique- the impact of climate parameters and thermal comfort conditions, heating bodies, additional elements and equipment, mechanisms of heat transfer; acquiring knowledge of methods for calculation of heat losses according to different standards and use these methods when developing main mechanical project of central heating systems.

learning outcomes
Students acquire specific skills and knowledge in heating technique: get familiar with elements of central heating systems; with heat losses calculation methods and can apply them in practice. Student can connect basic knowledge and apply it to solve concrete problems in the technique of heating.

theoretical teaching
Thermal parameters of the environment; thermal comfort conditions, characteristics of the external climate and the impact on thermal comfort conditions; calculation method for external project heating temperature; heat transfer through the building envelope construction, heat bridges, condensation, natural ventilation, wind effect on air infiltration, calculation of needed amount of heat for heating using different standards, heating equipment division, radiators and valves, types of heat transfer, heat radiators disclosure depending on the temperature of fluid; testing heaters; heating sources in central heating systems, insurance and boiler fittings, boiler room and its elements, open and closed expansion vessel; annual energy consumption calculation, the calculation of fuel consumption, different systems of central heating.

practical teaching
Auditory exercises consisting of several parts: heat transfer through the building envelope construction, determining the thickness of insulation, ventilation calculation of transmission and heat loss and sizing of heaters, boilers and related equipment, with the aim of making solo project task. Laboratory exercise is a demonstration - elements of the installation heating, valves, pipe insulation, thermal properties testing radiator. It is envisaged to visit the fair and techniques or factory that manufactures heating equipment.

prerequisite
Students are required to pass the exam "Thermodynamics B" in order to follow the course.

learning resources
Handouts - M. Todorović

Central heating systems design - B. Todorović

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
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: 15
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.
M. Todorović: Fundametals of heating techniques, handouts

THERMOMECHANICS

Thermodynamics B

Thermodynamics B

ID: BSc-0372
responsible/holder professor: Gojak D. Milan
teaching professor/s: Banjac J. Miloš, Gojak D. Milan, Komatina S. Mirko, Rudonja R. Nedžad, Todorović I. Ružica
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: oral
parent department: thermomechanics

goals
Understanding and acquiring the fundamental thermodynamic principles and laws, and knowledge of thermodynamic states and state changes of matters included in energy transformations processes. Understanding the principles of operation of thermal engines and refrigeration devices, and knowledge of fundamentals of the energy transfer by heat.

learning outcomes
Upon successful completion of this course students should be able to:

- Implement the law of conservation of energy for different processes in thermodynamic systems;
- Determine the properties of different substances (ideal gases and their mixtures, water–steam and other pure substances) as well as the performed work and amount of the transferred heat in different thermodynamic changes of state of substances;
- Implement the Second law of thermodynamics for processes in thermodynamic systems;
- Explain the thermodynamic principle of operation of heat engines and analyze basic heat engines cycles (Carnot, in IC engines, the gas-turbine and steam-turbine plants and others);
- Explain the thermodynamic principle of operation of refrigeration equipment and heat pumps and analyze the basic refrigeration cycles (Carnot, air and vapor compression cycles);
- Calculate and analyze the basic modes of heat transfer (conduction, convection, radiation, combined heat transfer phenomena).

theoretical teaching
Basic thermodynamic concepts. Thermodynamic system, state properties, state changes. Postulates of thermodynamics. Energy of the system, internal energy, modes of energy transfer, heat, work. Energy conservation law: First law of thermodynamics for closed system, heat capacity, enthalpy, First law of thermodynamics for open system. Second law of thermodynamics, entropy, reversible and irreversible thermodynamic processes. Ideal gas equation of state. Polytropic state changes of ideal gas. Mixtures of ideal gases. Real pure substances – water vapor: phases, diagrams of state, state changes. Cycles of heat engines; Carnot cycle; basic cycles of the internal combustion engines, gas-turbine and vapor-turbine power plants. Basic refrigeration cycles. Fundamentals of the energy transfer by heat: conduction, convection, radiation, combined transfer.

practical teaching
Determining the state properties. First law of thermodynamics for closed system, quantity of heat, performed work, thermodynamic system energy change. Specific heat capacity, specific heat capacities of gases. First law of thermodynamics for open system. Second law of thermodynamics, entropy change of the isolated thermodynamic system. Ideal gas equation of state. Polytropic state changes of ideal gas, examples, presentation in diagrams of state. Determining thermodynamic quantities and applying thermodynamic laws on mixtures of ideal gases. Real pure substances – water vapor: diagrams of state, state properties, state changes. Cycles of heat engines; basic cycles of the internal combustion engines, gas-turbine and vapor-turbine power plants. Basic refrigeration cycles. Numerical exercises of the energy transfer by heat.

prerequisite
As defined by the program of studies curriculum.

learning resources
1. Handouts

2. Vasiljević, B†, Banjac, M.: Handbook for thermodynamics – tables and diagrams, Faculty of Mechanical Engineering, Belgrade, 2020

3. Vasiljević, B†, Banjac, M.: A map for thermodynamics, Faculty of Mechanical Engineering, Belgrade, 2020.

4. Kozic, Dj.: Thermodynamics, Engineering Aspects, Faculty of Mechanical Engineering, Belgrade, 2019.

5. Laboratory for thermodynamics with installations and equipment.

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 32
auditory exercises: 24
laboratory exercises: 0
calculation tasks: 5
seminar works: 0
project design: 0
consultations: 3
discussion and workshop: 0
research: 0

knowledge checks: 13
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: 6
test, with assessment: 2
final exam: 2

assessment of knowledge (maximum number of points - 100)
feedback during course study: 0
test/colloquium: 60
laboratory exercises: 0
calculation tasks: 5

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

references

Milinčić, D., Voronjec, D.: Thermodynamics, Faculty of Mechanical Engineering, Belgrade (in Serbian)
Kozić, Đ.: Thermodynamics - engineering aspects, Faculty of Mechanical Engineering, Belgrade (in Serbian)
Vasiljević, B., Banjac, M.: Map for thermodynamics, Faculty of Mechanical Engineering, Belgrade (in Serbian)
Voronjec, D., Đorđević, R., Vasiljević, B., Kozić, Đ., Bekavac, V.: Solved problems in thermodynamics with extracts from theory, Faculty of Mechanical Engineering, Belgrade (in Serbian)
Đorđević, B., Valent, V., Šerbanović, S.: Thermodynamics with thermal engineering, Faculty of Technology and Metallurgy, Belgrade (in Serbian)

WEAPON SYSTEMS

- Classical Armament Design
- Classical Armament Design
- Flight Mechanics of the projectile
- Fundamentals of projectiles propulsion
- Introduction to Weapon Systems
- Missile weapons design

Classical Armament Design

ID: BSc-1384
responsible/holder professor: Jevtić T. Dejan
teaching professor/s: Jevtić T. Dejan
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: written
parent department: weapon systems

goals
Introducing students to the basics of construction of artillery weapons, small arms, automatic cannons, armoured vehicles and tanks. The study of basic tactical - technical requirements, processes that occur during firing, and the principles of operation, determining the structural solutions of certain systems. Analysis of individual structural elements of different classical armament systems.

learning outcomes
Mastering the basic principles of the design of classical armament systems. Qualification for the calculation of basic parameters of processes that determine the design of individual systems. The basis for the later detailed study of artillery and automatic weapons design.

theoretical teaching
Load on the artillery weapon carriage during firing. Types of gun mounts. A typical design and function principles of recoil braking systems. Basic types of construction solutions of gun barrels. Basic types and mechanisms of the breechblock. Types of devices on the gun mount. Basic characteristics and operating mechanisms of small arms. Automatic weapons based on the blow back operation. Automatic weapons with recoil operation. Recoil intensifiers and accelerators. Automatic weapons on the principle of gas operation. Types of locking and mechanical safety. Cartridge case extraction and ejection mechanisms, feed systems, trigger and firing mechanisms. Muzzle devices (muzzle breaks, flash hiders, silencers, muzzle deflectors). The characteristics of the construction of automatic cannons with their own or external power source. Concept and characteristics of self-propelled artillery weapons and tanks.

practical teaching
Load on the artillery weapon carriage during firing. Calculation of the recoil braking system. Calculation of gun barrels. Basic types and mechanisms of the breechblock. Automatic weapons based on the blow back operation. Characteristic examples of the function of automatic weapons with recoil operation and with gas operation. Types of locking and mechanical safety. Cartridge case extraction and ejection mechanisms, feed systems, trigger and firing mechanisms. Muzzle devices (muzzle breaks, flash hiders, silencers, muzzle deflectors).

prerequisite
There are no special conditions for attending the subject.

learning resources
1. Micković D.: Classical armament design - Handouts

2. Vasiljević M.: Automatic weapons, TŠC KoV JNA, Zagreb

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
auditory exercises: 28
laboratory exercises: 0
calculation tasks: 2
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks: 15
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

Handbook on Weaponry, Rheinmetal GmbH, Dusseldorf, 1982
Allsop D.F., Toomey M.A.: Small Arms - General Design, Brassey's, London, 1999

Classical Armament Design

ID: BSc-1325
responsible/holder professor: Todić N. Ivana
teaching professor/s: Todić N. Ivana
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: written
parent department: weapon systems

goals
Introducing students to the basics of construction of artillery weapons, small arms, automatic cannons, armoured vehicles and tanks. The study of basic tactical - technical requirements, processes that occur during firing, and the principles of operation, determining the structural solutions of certain systems. Analysis of individual structural elements of different classical armament systems.

learning outcomes
Mastering the basic principles of the design of classical armament systems. Qualification for the calculation of basic parameters of processes that determine the design of individual systems. The basis for the later detailed study of artillery and automatic weapons design.

theoretical teaching
Load on the artillery weapon carriage during firing. Types of gun mounts. A typical design and function principles of recoil braking systems. Basic types of construction solutions of gun barrels. Basic types and mechanisms of the breechblock. Types of devices on the gun mount.

Basic characteristics and operating mechanisms of small arms. Automatic weapons based on the blow back operation. Automatic weapons with recoil operation. Recoil intensifiers and accelerators. Automatic weapons on the principle of gas operation. Types of locking and mechanical safety. Cartridge case extraction and ejection mechanisms, feed systems, trigger and firing mechanisms. Muzzle devices (muzzle breaks, flash hiders, silencers, muzzle deflectors). The characteristics of the construction of automatic cannons with their own or external power source. Concept and characteristics of self-propelled artillery weapons and tanks.

practical teaching
Load on the artillery weapon carriage during firing. Calculation of the recoil braking system. Calculation of gun barrels. Basic types and mechanisms of the breechblock. Automatic weapons based on the blow back operation. Characteristic examples of the function of automatic weapons with recoil operation and with gas operation. Types of locking and mechanical safety. Cartridge case extraction and ejection mechanisms, feed systems, trigger and firing mechanisms. Muzzle devices (muzzle breaks, flash hiders, silencers, muzzle deflectors).

prerequisite
There are no special conditions for attending the subject.

learning resources
1. Micković D.: Classical armament design - Handouts

2. Vasiljević M.: Automatic weapons, TŠC KoV JNA, Zagreb

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
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: 15
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

Flight Mechanics of the projectile

ID: BSc-1083
responsible/holder professor: Todić N. Ivana
teaching professor/s: Todić N. Ivana
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: written
parent department: weapon systems

goals
Introducing students to the basics of flight mechanics, including aerodynamics, and its tasks. Setting up the basic equations of mechanics of flight and principles for solving them. Basic knowledge of the forces and torques acting on the missile during flight. Behavior on the trajectory: the stability of of the projectile, missile control methods. Application of the flight mechanics: preliminary weapon design, firing tables, fire control systems.

learning outcomes
Knowledge of principles and basic equations of mechanics of flight of the projectile. Ability to work on aerodynamic calculations and modeling the mechanics of flight of the projectile. Basic knowledge of stability and control methods.

theoretical teaching
Introduction to the mechanics of flight of the projectile; basic terms. The main tasks of the flight mechanics (primary and reversible). Trajectory elements and type of trajectories. External conditions (Earth's atmosphere and gravitational field) and the initial conditions. Coordinate frames and transformations. The basic equations of flight mechanic (Newton and Euler equations). The forces and torques acting on the projectile (gravitational, aerodynamic, propulsion and control). Aerodynamics as a special area of mechanics of flight; basic principles of missile aerodynamic. The aerodynamic coefficients and gradients. Methods aerodynamic control. Aerodynamic design. The basic calculation method of flight mechanic (approximate & numerical). Missiles behavior - stability and maneuverability (basic). Guided missiles and control methods (basic). Preliminary design of the missile. Firing tables. Fire Control Systems.

practical teaching
Earth's atmosphere and gravitational field (examples). Coordinate frames, transformation matrices (examples). Determination of initial firing elements. The basic equations of mechanics of flight, forces and torques acting on the projectile (examples). Approximate methods (Vacuum theory, Euler model,Siacci model, Tsiolkovsky model). Aerodynamic calculations methods. Aerodynamic design (examples). The basic mechanics of the flight calculation method (examples of approximate and numerical calculations). Preliminary design of the projectile (example). Application of the ballistic firing tables.

prerequisite
None.

It is desirable that the student has passed the mandatory mechanics.

learning resources
Blagojević, Đ.: Mechanics of flight of the projectile - the handout, Belgrade, 2010.

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 25
auditory exercises: 5
laboratory exercises: 0
calculation tasks: 10
seminar works: 5
project design: 0
consultations: 0
discussion and workshop: 5
research: 0

knowledge checks: 20
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: 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): 25

references

McCoy, R.L.: Modern Exterior Ballistics, Shiffer Publishing, 2012.
Janković, S.: Aerodinamika projektila, Mašinski fakultet Univerziteta u Beogradu, 1979
Boiffier, J.L., "The Dynamic of Flight The Equations", John Wiley & Sons Ltd. England, ISBN 0-471-94237-5, 1998

Fundamentals of projectiles propulsion

ID: BSc-1327
responsible/holder professor: Elek M. Predrag
teaching professor/s: Elek M. Predrag, Jevtić T. Dejan
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: written
parent department: weapon systems

goals
Introducing students to the basics of projectile propulsion, including classic and rocket propulsion. Study of fundamental processes that occur during firing in the gun barrel and in the rocket motor chamber. Influence of characteristics of propellants on firing processes. Setting up a system of equations describing these processes and methods for solving the system. Application of propulsion software packages. Design of propellant systems.

learning outcomes
Student gets knowledge of principles and basic equations of the propulsion. Student is trained for the calculation of basic parameters of interior ballistics and rocket propulsion. Student acquires fundamentals for subsequent detailed study of various types of propulsion.

theoretical teaching
1. Introduction to propellant systems.

2. Classification of propulsion systems (classical and rocket).

3. Gunpowder. Propellant charge. Physical, chemical and ballistic characteristics of gunpowder. Combustion of gun propellant.

4. Basic processes and laws during the firing process. The main tasks of the internal ballistics.

5. Energy balance during the firing process. The basic equations of interior ballistics. Corrective formulas of interior ballistics.

6. Basics of reactive propulsion; classification of reactive propulsion (air-breating and rocket); classification of rocket propulsion (liquid, solid and hybrid).

7. The basic equations of propulsion systems performances.

8. Fundamentals of air-breathing propulsion.

9. Fundamentals of rocket engines with liquid propellants.

10. Fundamentals of rocket motors with solid propellants.

11. Software packages for reactive motor performance calculation.

practical teaching
1. Combustion of gunpowder. Examples of calculations

2. The main tasks of the interior ballistics. Energy balance during the firing. The basic equations of interior ballistics. Solving problems.

3. Corrective formulas of interior ballistics. Selected examples.

4. The basic equations of propulsion systems performances. Problems

5. Fundamentals of rocket engines with liquid propellants. Selected examples

6. Fundamentals of rocket propulsion with solid propellants. Selected examples

7. Software packages for reactive motor performance calculation. Examples and demonstrations.

prerequisite
No obligatory prerequisites. Passes exam preferred: Fundamentals of weapon system design.

learning resources
1. Jaramaz, S., Mickovic, D.: Interior ballistics, Faculty of Mechanical Engineering, Belgrade, 2011. (in Serbian)

2. Blagojevic, Dj., Milinovic, M.: Scripts for lessons - Rocket propulsion

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
auditory exercises: 12
laboratory exercises: 6
calculation tasks: 12
seminar works: 0
project design: 0
consultations: 0
discussion and workshop: 0
research: 0

knowledge checks: 15
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

Introduction to Weapon Systems

ID: BSc-1295
responsible/holder professor: Elek M. Predrag
teaching professor/s: Elek M. Predrag
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: written
parent department: weapon systems

goals
The main objective of this course is to introduce students to the field of weapons systems. Students get basic knowledge in the field of defense technologies, and learn the classification,purpose, importance and basic principles underlying the modern weapon systems. Gain insight into the complexity and variety of weapons systems and get a clear overview of this multidisciplinary field.

learning outcomes
Student gets the necessary basic knowledge of weapons systems that include classification, purpose and key principles of their action.

Student has a complete overview of the field of classical and rocket weapon systems.

theoretical teaching
1. Development of conventional weapons systems,

2. Classic weapons (small arms, artillery weapons, anti-armor systems, air-defense systems),

3. Ammunition (division of projectiles, explosives, small arms ammunition, high-explosive

missiles, KE projectiles, shaped charge projectiles, cargo ammunition, fuzes),

4. Platform of weapon systems (tanks, classification of other armored vehicles),

5. Rocket systems (the basic principle of rocket motion, classification and characteristics of

military rocket and missile systems, the main characteristics of anti-armor missile, air-defense

missiles, the main characteristics of artillery rocket systems MLRS)

6. Data acquisition systems,

7. Fire control systems,

8. Guidance and control of missiles.

practical teaching
1. Classic weapons - analysis and comparison of solutions implemented in practice,

2. Ammunition - types of projectiles, the main characteristics, the analysis of realized designs

3. Platform of weapon systems - the analysis of implemented solutions, comparison,

4. rocket systems - fundamentals of rocket motion, types of missiles, the analysis of realized designs

5. Data acquisition systems - examples of sensors and their analysis

6. Fire control systems - an analysis of different types of FCS

7. Guidance and control of missiles - Analysis and comparison of different types of guidance and control systems.

prerequisite
None.

learning resources

1. Handouts for lessons

2. Arsic, S.: Contemporary armament, Belgrade, 1996 (in Serbian)

3. Petrovic, D.: World artillery, Belgrade, 2002,(in Serbian)

4. Andjelkovic, M.: Fundamentals of rocket engineering, Belgrade, 2005, (in Serbian)

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
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: 15
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

Missile weapons design

ID: BSc-1296
responsible/holder professor: Marković D. Miloš
teaching professor/s: Marković D. Miloš
level of studies: B.Sc. (undergraduate) academic studies – Mechanical Engineering
ECTS credits: 6
final exam: written+oral
parent department: weapon systems

goals
Goal of subject is to achieve competitive academic knowledge and skills in the analyzes and syntheses of the main missiles and rocket system performances. Also, goal is to realize knowledge about special missile and rocket performances, as the special flight vehicle and ballistic object, with their distinguishing features, applicable for weapon or ammunition syntheses comparing with other types of weapon and projectiles. Student or applicant developing creative capabilities, in the directed mechanical engineering, skills for the basic professional orientation of weapon design engineering. Theoretical applications and practical examples of missile, rockets diversification and integration design cases is the knowledge goal of student creative course work, as the bachelor basic knowledge of weapon designers.

learning outcomes
Student achieve possibilities of analyzes and syntheses for the expert solutions of weapon missile and rocket systems, project, design, feasibility and other study approaches integrations.Output includes methodology and proceedings of specific research knowledge of mathematics, mechanics, propulsion , propellants and its software applications in missiles systems design. Student developing critical approach of weapon missiles system and design and possibility to employ knowledge in practical work also, in information exchanging about relevant references. Also, understand principal performances of missiles and rocket weapon systems and differences its design differences and applied different technologies and branches of research in this area.

theoretical teaching
Classification of missiles. Missile structure and airframe properties. Basic concepts of unguided missiles. Basic concepts of guided missiles. Mass and propulsion consideration in missile design. Flight performance considerations in missile design. Rocket motor design. Aerodynamic considerations in missile design. Basic analyzes of guidance laws and their influence on missile design. Fundamentals of autopilot and role in missile design. Fundamentals of missile control systems. Missile loads during flight. Missile component stress analyses.

practical teaching
Matlab basic. Analyses of unguided missiles: 1) Setup tactical-technical requirements trough flight dynamics with 2DOF, 2) warhead consideration in unguided missile design, 3) solid rocket motor consideration in missile design, 4) unguided missile aerodynamic, 5) missile stress analysis, 6) flight dynamics with 3DOF.

Analyses of guided missiles. Define tactical -technical requirements and selection guidance law in guided missile design (simulations). Basic principles of homing sensors. Basic principles of missile autopilot and his influence in missile design (simulations). Basic analyses of guidance laws (simulations). Basic principles and analyses of electromechanical control systems (mathematical modeling and simulations).

prerequisite
No requirements.

learning resources
Miloš Marković: Handout - Missile design, 2020.

number of hours: 75

active teaching (theoretical): 30
lectures: 20
elaboration and examples (revision): 10

active teaching (practical): 30
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: 15
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: 7
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: 10
calculation tasks: 30
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references
E. Fleeman, Missile design and system engineering. American Institute of Aeronautics and Astronautics, 2012.
Moore F.: Approximate methods for weapon aerodynamics. Progress in Astronautics and Aeronautics, 2000.
Chin S.: Missile configuration design, The McGraw-Hill Book Company, 1961.
MILITARY HANDBOOK: DESIGN OF AERODYNAMICALLY STABILIZED FREE ROCKETS, MIL-HNDBK-762(MI), 1990.
Zarchan P.: Tactical and Strategic Missile Guidance, Volume 239, Progress in Astronautics and Aeronautics, 2012.