Course catalog
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Optimization of aerospace structures
Optimization of Thermal Power Plants
Organization and methods of scientific research and communication
Oscillations of mechanical systems
Performance Analysis of Manufacturing Systems
Planning, Performing & Controlling Projects
Power transmission of locomotives - control and optimization
Principles and Concepts of Industrial Air Pollution
Principles of modeling in process engineering
Product Development in Mechanical Engineering
Production Planning and Control Systems
Propulsion of projectiles
Quality Engineering Techniques
Quantitative Research Methods in Aviation
Queuing Systems - Theory and Applications
Regimes and energy efficiency of thermal power plants
Rehabilitation Biomechanics
Reliability and dynamics of power transmission units
Research and Development Methodology
Risk Management
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Selected chapters of mechanics
Selected chapters of mechanics of robots
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Selected Topics in Aerodynamics
Selected topics in aeroelasticity
Selected topics in aircraft composite structures
Selected Topics in Bionics
Selected topics in fluid structure interaction
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Wave Induced Loads on Ships

The dynamics of a viscous incompressible fluid
Actuating Systems - Selected Topics

ID: PhD-3553
**teaching professor:** Miloš V. Marko
**level of studies:** Ph.D. (doctoral) studies
**ECTS credits:** 5
**final exam:** written

**goals**

To qualify students to perform complex modeling and simulation of various types of actuating systems independently.

**learning outcomes**

Students will gain knowledge that will qualify them for laying-out (designing).

**theoretical teaching**

1. Advanced design algorithms
2. Sensors
3. Digital measuring systems
4. Improved Methods for selection of the components
5. Control requirements, control system & stability
6. Mathematical modeling
7. Simulations

**practical teaching**

Modeling and simulation of complex actuating systems.
After completion of the modeling and simulation, practical work with different actuating systems.
Also, visiting to Department of Automatic Control of Faculty of Mechanical Engineering.

**prerequisite**

Using of MATLAB® i Simulink®.
Using of 3D CAD design software (any).

**learning resources**

Moodle (Modular Object-Oriented Dynamic Learning Environment, a free, open-source PHP web application for producing modular internet-based courses that support a modern social constructionist pedagogy).
Lectures, power point presentations, romm equipped with computers & software for design and simulations, labs, handouts.

**number of hours**

lectures: 35
research: 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: 70
project design: 0
final exam: 30
requirements to take the exam (number of points): 0

references

M. Milos, Advanced Topics in Actuating Systems, professor's handouts
E. Doeblin, Measurement Systes, Application and Design – McGraw-Hill
A. VanDoren, Data Acquisition Systems, Reston Publishing Co., Inc.
Adaptive Structures

**ID:** PhD-3254  
**teaching professor:** Simonović M. Aleksandar  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written

**goals**

Study of theoretical backgrounds and applying of advanced research methods related to adaptive structures. Development of creative abilities for R&D and specific engineering problems approach using contemporary adaptive structures design and analysis methods.

**learning outcomes**

Vast and comprehensive field of adaptive structures is covered with contemporary topics. Advanced adaptive structures topics included, enable extended analysis and design of adaptive structures of various types and purposes.

**theoretical teaching**

Comply with the subject of the research of the candidate's doctoral thesis

**practical teaching**

Contents of exercises follows the exposed material.

**prerequisite**

There is no necessary requirement for attendance of Adaptive Structures.

**learning resources**

Simlab - computer laboratory

**number of hours**

lectures: 35  
research: 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: 70  
project design: 0  
final exam: 30  
requirements to take the exam (number of points): 0

**references**
T. H. Brockmann, THEORY OF ADAPTIVE FIBER COMPOSITES, Springer, 2009

Selected Journal Articles
Advanced Airframe Structural Analysis

ID: PhD-3457

teaching professor: Grbović M. Aleksandar

level of studies: Ph.D. (doctoral) studies

ECTS credits: 5

final exam: written

goals

The Advanced Airframe Structural Analysis course aims to provide a deeper insight into the theory of structural analysis as applied to vehicles, aircrafts, spacecrafts and ships. The emphasis is on the application of advanced concepts of structural analysis in everyday engineering practice. Coverage of elasticity, energy methods and virtual work set the stage for discussions of airworthiness/airframe loads and stress analysis of aircraft components. Also, the use of FEM and XFEM in airframe structural analysis is given briefly.

learning outcomes

Purpose of the course is to provide clear instruction in the advanced concepts of the theory of structural analysis as applied to vehicular structures. Course offers review of the fundamental concepts as well as explanations and applications of advanced structural analysis concepts in everyday practice. This course will give students an appreciation of the criteria used for selecting aircraft materials and designing aircraft structures. Students will get an overview of how structural loading and stress analysis influence the decisions upon aircraft shape and airworthiness. It is intended for students who need to be aware of the influence of aircraft materials and structural considerations in the development of aircraft design.

theoretical teaching

2. Introduction to the Theory of Elasticity: Review.
5. Energy-Based Numerical Solutions.
6. Introduction to the Finite Element Method and Extended FEM.

practical teaching

During practical work students will learn different "manual" methods as well as computer based methods for solving typical airframe structural analysis problems.

prerequisite

A background in the elements of the theory of elasticity is essential, as well as the knowledge concerning engineering statics and dynamics.

learning resources
Handouts, Virtual classroom (Moodle), Powerpoint presentations, Recommended literature and websites.

**number of hours**

lectures: 35  
research: 0

**assessment of knowledge (maximum number of points - 100)**

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

**references**

A. Grbovic: Handouts, Faculty of Mechanical Engineering, Belgrade 2010.  
Advanced computer aided design

**ID:** PhD-3455  
**teaching professor:** Grbović M. Aleksandar  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written

**goals**

The Advanced Computer Aided Design course aims to provide candidates with advanced computer aided design and drafting skills, including parametric modeling, as well as a detailed understanding of the main steps and design activities involved in the mechanical design processes.  
The Advanced Computer Aided Design course will provide some ‘in-depth’ guidance for students who want to learn methods for creation of complex 3D parts and assemblies, as well as generation of accurate CAD drawings which should define students’ design work.  
During the course, the students will be trained using CATIA v5 software, and will learn the following modules in detail: Sketcher, Part Design, Drafting and Assembly.

**learning outcomes**

The Advanced Computer Aided Design is a course for students who wish to acquire a comprehensive advanced 3D-CAD skills and a recognised qualification that can provide the basis for professional development in a mechanical design related fields.  
By completing this course, the students will be able to create simple and complex mechanical parts and assemblies within CATIA v5 environment, as well as precise drawings of designed parts/assemblies with all necessary dimensions and views.  
At the end of the course, the students will also be able to prepare their 3D models for further work (i.e. finite element analysis of parts and assemblies or tool design) and will have enough skills to attend another courses in CAD design (for example, surface design and sheet metal design).

**theoretical teaching**

Review of Part Design & Sketcher Fundamentals:  
Part Design Screen; Pull-down Menus; Toolbars in Part Design; Part Design Workbench; Sketcher Workbench; Creating a new part with a new sketch.

Creating Basic Shapes:  
Rectangle, Oriented Rectangle, Parallelogram, Elongated Slot, Elongated Curved Slot, Keyhole, Hexagon, Circle, Circle through 3 points, Circle with Cartesian coordinates, Circle tangent to 3 elements, Arc through 3 points, Arc through 3 points using limits, Arc, Spline, Connect Curve, Ellipse, Parabola, Hyperbola, Conic, Line, Unlimited Line, Bi-tangent Line, Bisect Line, Axis, Point, Point using coordinates, Equidistant points, Intersection Point, Projection Point.

Advanced Part Design Tools:  
Holes/Pockets/Pads not normal to sketch plane, Creating Grooves, Creating Ribs and Slots, Creating Stiffeners, Creating Lofts, 3D Wireframe, Surface Based Features, Advanced Draft, Thickness, Using Transformations, 3D Constraints, Local Axis, Annotation, Part Analysis.
Part Management: Measure, Mean Dimensions, Scan, Parents-Children, Cut, Paste, Isolate, Break, Inserting and Managing Bodies, Multi-Model Links, Scaling.

Advanced Drafting: Views generation, Set the angle projection, Set the fillet generation, Additional views, Offset section view, Offset section cut, Detailed drafting.

Review of Assembly Design Fundamentals: Assembling Components, Positioning Components, Coincidence Icon, Contact Icon, Offset Icon, Fix Icon, Fix Together Icon, Analysing the assembly, Editing the assembly, Working with components, Creating the structure by inserting components, Positioning the components

Advanced Assembly Design: Managing Scenes, Distance, Sectioning and Clash, Generating Reports, Generating Annotations, Working with Large Assemblies, Designing & Managing Contextual Parts, Creating and Using Published Geometry.

CATIA Parameters and Formulas: Connecting CATIA with Excel; Design Tables.

practical teaching
All topics mentioned in Theory Section will be practiced on computers with installed CATIA v5 software. Every icon (option) and design method will be demonstrated by lecturer and students will repeat the same steps in order to acquire skills necessary to pass the final exam.

prerequisite
No previous CAD experience or skills are required, although experience in CATIA v5 would be an advantage.

learning resources
Handouts, Virtual classroom (Moodle), Power Point presentations, Computers with CATIA v5 software, Recommended literature and websites.

number of hours
lectures: 35
research: 0

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: 20
final exam: 30
requirements to take the exam (number of points): 50
references

A. Grbovic: Handouts, Faculty of Mechanical Engineering, Belgrade 2010.
Advanced Course in Numerical Methods for Ship Strength Analyses

**ID:** PhD-3188  
**teaching professor:** Motok D. Milorad  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** project design

**goals**

Learning methods for structural analyses of advanced ship structures.

**learning outcomes**

Student will be capable of conducting structural analyses of advanced ship structures using commercial software. The emphasis is on static and dynamic analyses of steel and composite structures using finite element method (FEM).

**theoretical teaching**

Advanced FEM technics. Calculation of basic modes of free hull girder oscillations. FEM analyses of ship hulls made of composite materials.

**practical teaching**

Training for use of commercial FEM software in solving above explained tasks.

**prerequisite**

Defined by the curriculum of studies.

**learning resources**

1. Commercial FEM computer programs  
2. Instruction manual for commercial FEM programs use /In English/

**number of hours**

lectures: 35  
research: 0

**assessment of knowledge (maximum number of points - 100)**

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

**references**
**Advanced course of Mechanical and hydromechanical Operations and Equipment**

**ID:** PhD-3481  
**teaching professor:** Obradović O. Marko  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written

**goals**

The aim of the course is that students gain some knowledge about the processes, apparatus and devices for mechanical and hydro-mechanical operations, to prepare for further theoretical and experimental research in the PhD.

**learning outcomes**

After completing the course student will have theoretical and practical knowledge of common processes, apparatus and devices for mechanical and hydro-mechanical operations, in order to prepare further theoretical and experimental research in the PhD thesis. Students will be able to apply acquired knowledge in their further scientific research and professional work. After completion of the course it is expected that the candidate has mastered the scientific knowledge related to the analysis and evaluation of scientific papers, ways and methods of analysis of certain processes, laboratory work, as well as advanced process modeling in the field of mechanical and hydro-mechanical operations.

**theoretical teaching**


**practical teaching**

Students work under the supervision of teacher one seminar paper that needs student to apply knowledge.

**prerequisite**

There are no special requirements. For students whose doctoral thesis in the field of mechanical and hydro-mechanical equipment and operations.

**learning resources**

3. Knežević Dinko: Mineral processing, University of Belgrade, Faculty of Mining and Geology, Belgrade, 2012.
4. Ćalić Nadežda: Principles of mineral processing, University of Belgrade, Faculty of Mining and Geology, Belgrade, 1990.
6. Laboratory installation for coal grindability
7. Laboratory installation for determining the physical properties of granular materials
8. Laboratory installation for fluidization of granular materials.

**number of hours**

lectures: 35
research: 0

**assessment of knowledge (maximum number of points - 100)**

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

**references**

***: Basics in Minerals Processing, Metso Corporation, 2015.
Advanced Digital Control Systems

ID: PhD-3024
teaching professor: Bučevac M. Zoran
level of studies: Ph.D. (doctoral) studies
ECTS credits: 5
final exam: written

goals

Mastering with: advanced techniques for analysis and synthesis of digital control systems

learning outcomes

Knowledge of advanced techniques for analysis and synthesis of digital control systems.

theoretical teaching


practical teaching

• Direct tracking of the course theory through the illustrative examples,
• Define and elaborate of the task of seminar paper,
• Consultation.

prerequisite

There are no requirements.

learning resources

• Manuscript at http://au.mas.bg.ac.rs/Nastava-Kau/Nastava_Download.htm
• Digital computer.

number of hours

lectures: 35
research: 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: 70
project design: 0
final exam: 30
requirements to take the exam (number of points): 30
references

Advanced Gasdynamics

**ID:** PhD-3565  
**teaching professor:** Milićev S. Snežana  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written

**goals**

The goal of this course is to acquire knowledge about some aspects of the compressible flows and mastering of mathematical methods for modeling these flows present in a variety of practical problems.  
The student should:
1. acquire adequate theoretical knowledge in the field of advanced gas dynamics;  
2. be trained to perform calculations of compressible flows;  
3. become familiar with the preparation and procedures for experimental research in gas dynamics.

**learning outcomes**

Attendance and regular monitoring of the theoretical and practical training the student should master the basic knowledge in the field of gas dynamics. This will enable him, on the one hand, to solve specific engineering problems in the elementary problems of compressible flows, and, on the other hand, help him to better understand other courses based on this scientific area.

**theoretical teaching**

Flow through the nozzle. Equations for isentropic flow with varying cross-section.  
Convergent and de Laval nozzle - regimes of flow in the nozzle.  

**practical teaching**

Application of the basic equations of gas flow. Speed of sound. Critical and total values of physical quantities. Assessing the impact of compressibility.  
Non-isentropic flows. Calculation of adiabatic flows of viscous gas. Calculation of isothermal
flow of viscous gas. Calculation of inviscid flows with heat transfer. Linearized airfoil theory.

**prerequisite**

Passed exam in course Fluid Mechanics and Thermodynamics

**learning resources**


**number of hours**

- lectures: 35
- research: 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: 60
- project design: 0
- final exam: 40

Requirements to take the exam (number of points): 50

**references**

Handouts
Tables for calculation of compressible flows with theoretical handouts, Snežana S. Milićev, Aleksandar S. Ćoćić, Faculty of Mechanical Engineering, 2017.
Compressible Fluid Flow, M. A. Saad
Advanced Gas Dynamics

**ID:** PhD-3556  
**teaching professor:** Bengin Č. Aleksandar  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written

**goals**

Basics of compressible aerodynamic is taught in this course. Students will be able to apply quasi one-dimensional stream-tube flow equations to typical compressible aerodynamic problems. Unsteady compressible flow is also studied. Two-dimensional calculations of diffuser and nozzle flows are mastered.

**learning outcomes**

Upon completion and passing the Course the student expected to understand the basic characteristics of compressible flows including: wave and wave propagation; analyze isentropic compressible flows as well as effects of friction and heat transfer; analyze normal shock, oblique shock and Prandtl-Meyer flows; learn the development of thermodynamic and flow relationships and apply these to practical problems; become familiar with application-type problems in gas dynamics.

**theoretical teaching**

One-dimensional unsteady flows, including analysis of unsteady interactions in time-distance and pressure-velocity planes; plane shock waves; steady two-dimensional flows, including subsonic similarity rules, supersonic turning processes, method of characteristics, oblique and bow shocks; a related topic chosen by the class.

**practical teaching**

Practical part of Course demonstrate the numerical examples in all ranges of high speeds. Practical work of students is realized through solution of individually selected homework problems for each student. Course materials are available to students as well as example problems.

**prerequisite**

None

**learning resources**

Classroom, projector, laptop

**number of hours**

lectures: 35  
research: 0

**assessment of knowledge (maximum number of points - 100)**
feedback during course study: 10
lab experiment: 0
laboratory exercises: 0
calculation tasks: 50
seminar works: 20
project design: 0
final exam: 20
requirements to take the exam (number of points): 50

references

Ascher H. Shapiro: Dynamics and Thermodynamics of Compressible Fluid Flow (volumes I and II), Ronald, 1995
J. John, T. Keit: Gas Dynamics, Pearson Hall, 2006
Advanced linear systems

**ID:** PhD-3410  
**teaching professor:** Ristanović R. Milan  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** seminar works

**goals**

To introduce students to modern techniques of analysis and synthesis of linear systems for various classes of systems.

**learning outcomes**

Students learn to analyze and design of linear systems with modern control techniques and monitoring of modern literature.

**theoretical teaching**

A review of linear algebra, and of least squares problems.  
Representation, structure, and behavior of multi-input, multi-output (MIMO) linear time-invariant (LTI) systems.  
Robust stability and performance. Approaches to optimal and robust control design.

**practical teaching**

Solving of practical problems in Matlab and Simulink.

**prerequisite**

The academic level of knowledge of the theory of linear systems.

**learning resources**

- Literature on the website "Automatic control"
- Licensed Software in the possession of the Faculty.
- Freeware software.
- PCs.
- Laboratory of automatic control
- Rotary inverted pendulum
- NI cRIO.

**number of hours**

lectures: 35  
research: 0

**assessment of knowledge (maximum number of points - 100)**
feedback during course study: 0

laboratory exercises: 0
calculation tasks: 0
seminar works: 50
project design: 0
final exam: 50
requirements to take the exam (number of points): 0

references

Advanced Manufacturing Systems

**ID:** PhD-3364  
**teaching professor:** Miljković Đ. Zoran  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** seminar works

**goals**

The aim of the course is to provide a framework, specific methods and tools for the selection and configuration of the capacity of Advanced Manufacturing Systems (AMSs). Course includes the ideal guide for a researcher/designer who wants to avoid the most common mistakes while consistently maximizing the accuracy and performance of next-generation manufacturing systems. The decision making framework and tools illustrated in this course combine decision-making theory, optimization theory, discrete event simulation and the system of neural networks implementation. 

The specific goals of this course follow:  
- To show PhD students how to create valid and realistic intelligent robotized manufacturing;  
- To study a practical guide to next-generation manufacturing systems, for example Biological Manufacturing Systems (BMS);  
- To give PhD students insight into decision models of capacity planning problem (type, configuration, resources, etc.).

**learning outcomes**

The course Advanced Manufacturing Systems covers all the basic concepts in accordance with new methods based on AI techniques and explains how to create and manage the capacity planning, and complete the planned process using finishing and final assembly techniques as well as intelligent material handling mobile robot activities for industrial purpose within the plant.

**theoretical teaching**

The course Advanced Manufacturing Systems presents new methods and approaches for understanding the world of next-generation manufacturing, where every aspect of intelligent agents must be highly responsive to production researcher/designer needs in the 21st century.

The main topics of the course contain the decision-making models in domain of the capacity planning problem, from the decision on the type of manufacturing systems to adopt to their detailed configuration in terms of resources (manufacturing processes, machine tools, tools and tooling, industrial robots/mobile robots, buffers/warehouses, etc.).

Main topics of the course are:  
- Advanced Manufacturing Systems (AMSs) - Role and Scope.  
- A Framework for Long Term Capacity Decisions in AMSs.  
- Configuration of AMSs.  
- Selecting Capacity Plan.  
- Planning and Scheduling.  
- Intelligent Industrial Robots in AMSs - Configurations; Kinematics; Machine Intelligence/Machine learning; Sensors (especially camera), etc.  
- Mobile Robots in AMSs - Locomotion; Kinematics; Mobile robotic exploration aiding object search in indoor environment - plant environment; Material handling system consisting of
multiple mobile robots for complex transportation task in the reconfigurable manufacturing systems, etc.

**practical teaching**

Relevant practical topics include mobile robots and camera implementation in AMSs:
* Configuration of Robotized AMS; Laboratory work.
* Planning and Scheduling within Robotized AMS (especially indoor transportation); Calculation/Optimization.
* Mobile Robot Perception (image processing/camera calibration); Laboratory work.
* Vision-based Mobile Robot Localization and Navigation in AMS; Laboratory work.
* Path Planning and Obstacle Avoidance for Autonomous Mobile Robots; Laboratory work.
* Mobile Robot - Material handling and Indoor transportation; Laboratory work.

**prerequisite**

MSc degree of technically oriented faculty.

**learning resources**

[1] Software packages (BPnet, ART Simulator, MATLAB, AnyLogic, Flexy), Laboratory CeNT, University of Belgrade, Faculty of Mechanical Engineering, 18.13
[2] Laboratory mobile robot prototype (Khepera II mobile robot with gripper and camera; LEGO Mindstorms NXT and LEGO Mindstorms EV3 Sets of reconfigurable mobile robots equipped with sensors and microcontrollers), Laboratory CeNT, University of Belgrade, Faculty of Mechanical Engineering, 18.12
[3] Laboratory model of designed manufacturing system, Laboratory CeNT, University of Belgrade, Faculty of Mechanical Engineering, 18.12

**number of hours**

lectures: 35
research: 0

**assessment of knowledge (maximum number of points - 100)**

feedback during course study: 15
test/colloquium: 0
laboratory exercises: 10
calculation tasks: 0
seminar works: 35
project design: 0
final exam: 40
requirements to take the exam (number of points): 40

**references**
Andrea Matta, Quirico Semeraro, (editors), (2005) DESIGN OF ADVANCED
MANUFACTURING SYSTEMS, Springer.
R. Siegwart, I. R. Nourbakhsh, D. Scaramuzza, (2011) INTRODUCTION TO AUTONOMOUS
AUTONOMOUS MOBILE ROBOTS, The MIT Press.
M. P. Groover, (2001) AUTOMATION, PRODUCTION SYSTEMS, AND COMPUTER-
W. Van de Velde (editor), (1993) TOWARD LEARNING ROBOTS, MIT Press, Special Issues of
Advanced Methods for Maintenance of Railway Vehicles

**ID:** PhD-3139  
**teaching professor:** Lučanin J. Vojkan  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written

**goals**

The aim of the course is to introduce students with specific problems in the maintenance of rolling stock and facilitate the acquisition of knowledge necessary to make the work in this field. Upon completion of the course it is expected that the student will be able to identify and analyze specific problems in the field of maintenance and will be able to serve the mathematical formulas and models in finding appropriate solutions.

**learning outcomes**

The aim of the course is to introduce students with specific problems in the maintenance of rolling stock and facilitate the acquisition of knowledge necessary to make the work in this field. Upon completion of the course it is expected that the student will be able to identify and analyze specific problems in the field of maintenance and will be able to serve the mathematical formulas and models in finding appropriate solutions.

**theoretical teaching**


**practical teaching**

Nothing

**prerequisite**

Finished course in statistics field in previous studies.

**learning resources**

Literature that is available in the Faculty Bookstore and Library; Handouts available on lectures; Internet resources (KOBSON).
number of hours

lectures: 35
research: 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: 70
project design: 0
final exam: 30
requirements to take the exam (number of points): 0

references

Advanced Nuclear Reactors

**ID:** PhD-3527  
**teaching professor:** Stevanović D. Vladimir  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** seminar works

**goals**

Acquiring knowledge on principles and methods for development of advanced nuclear reactors with improved safety features and economics. An overview of research requirements within developments of advanced reactors.

**learning outcomes**

Ability to define topics and contents of research with the aim of designing advanced nuclear reactors. Application of a specific thermal-hydraulic method for a design of defined technical features of an advanced reactor.

**theoretical teaching**


**practical teaching**

Application of a thermal-hydraulic method for the analysis and design of a specific nuclear reactor feature. Evaluation of advanced reactors design characteristics and improvements regarding improved safety features and economics of operation.

**prerequisite**

Passed exams in Thermodynamics, Fluid Mechanics, Higher Mathematics and the basic course in Nuclear Reactors at Bachelor or Master studies.

**learning resources**

Lecture notes, computer equipment, in-house and commercial computer codes for thermal-hydraulic analyses.

**number of hours**

lectures: 35  
research: 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: 60
project design: 0
final exam: 30
requirements to take the exam (number of points): 0

references

Advanced Numerical Methods

ID: PhD-3555
teaching professor: Svorcan M. Jelena
level of studies: Ph.D. (doctoral) studies
ECTS credits: 5
final exam: oral

goals

Detailed acquaintance and implementation of advanced numerical methods adequate for solving a specific engineering problem closely related to the student’s research topic. Throughout the course various software packages or programming languages can be used or a personal code can be developed.

learning outcomes

Familiarization with the existing numerical methods and possibilities of their coupling. Recognition of the most significant influences to the problem that is being modeled. Choice and rational understanding of the adequate numerical set-up as well as boundary conditions definition. Individual work in the form of numerical computation of the unknown physical quantity (quantities) and post-processing. Work in different research areas - applied mathematics, programming, computational fluid dynamics, fluid-structure interaction, optimization, automation, etc. and their coupling.

theoretical teaching

In accordance with the selected research topic.

practical teaching

In accordance with the selected research topic.

prerequisite

There are no mandatory conditions/prerequisites for course attendance.

learning resources

Classroom, computer (laptop), projector.

number of hours

lectures: 35
research: 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: 70
final exam: 30
requirements to take the exam (number of points): 0

references


Additional materials
Advanced robotics-selected chapters

ID: PhD-3127

**teaching professor:** Lazarević P. Mihailo

**level of studies:** Ph.D. (doctoral) studies

**ECTS credits:** 5

**final exam:** oral

**goals**

Introduce students to basic concepts of kinematics and dynamics of advanced robotic systems. It is possible to solve kinematics and dynamics tasks as well as control task of the robot system (RS)-(redundant RS, obstacle avoidance, task planning and navigation, robot vision) based on applications of intelligent methods of control as well as using modern theory based on Rodriguez transformation matrix, quaternions as well as the theory of finite rotations. Determination (simulation) models of RS - i.e. differential equations of motion of the RS, which are important in practical problems of the RS. Practical simulations RS using MATLAB, Cyberbotics Webots software package and students work with laboratory robot NEUROARM.

**learning outcomes**

By attending this course student acquires the ability to analyze problems and synthesis solutions to the problem of kinematics and dynamics of robotic systems using scientific methods and procedures as well as computer technology and equipment. This enabled him applying solutions to practical problems of robotic systems as well as monitoring and implementation of innovation in the development of new robotic systems.

**theoretical teaching**


**practical teaching**

Examples of determining the number of degrees of motion of the RS; Calculation the Rodriguez transformation matrix (MT)- typical cases, determination of kinematic characteristics of the RS in MATLAB environment. Solving the direct and inverse kinematic task of RS. Solving the direct and inverse dynamics task of the RS in MATLAB environment. Examples of DIFE of RS simulation in MATLAB-GUI, MATHEMATICA environment, an example of a redundant RS. An example of simulation RS using Cyberbotics Webots package. Example of control of the RS-laboratory robot NeuroArm with 7 degrees of freedom in the...
MATLAB environment. A example of video-servo control of RSSimulation and control of LEGO Mindstorms robots.

**prerequisite**

none

**learning resources**

1. Čović M. V. Lazarević, Mechanics of Robot, MF Belgrade, 2009.(Book)
2. Lazarević M. Exercises in mechanics of robot, MF Belgrade, 2006.(ZZD)
6. Cyberbotics Webots - software package
8. MATLAB, MATHEMATICA - mathematics software packages

**number of hours**

lectures: 35
research: 0

**assessement of knowledge (maximum number of points - 100)**

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

**references**

Yoseph Bar-Cohen, Cynthia L. Breazea, Biologically Inspired Intelligent Robots, SPIE org, 2003
Advanced Systems in Intelligent Buildings

**ID:** PhD-3413  
**teaching professor:** Ristanović R. Milan  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written

**goals**

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

**learning outcomes**

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

**theoretical teaching**


**practical teaching**

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

**prerequisite**

Basic automatic control knowledge and digital systems.

**learning resources**

M. Ristanovic, Intellingent Buildings, printed lectures  
Laboratory for Intelligent Buildings  
KNX/EIB Trainings Kit  
ETS3 - licensed software
number of hours

lectures: 35
research: 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: 50
project design: 0
final exam: 50
requirements to take the exam (number of points): 0

references

C.F. Mueller, Regelungs- und Steuerungstechnik in der Versorgungstechnik, 2002
Advanced techniques in IC Engine testing

**ID:** PhD-3422  
**teaching professor:** Miljić L. Nenad  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** seminar works

### goals

The goal of this course is to provide a student with the comprehensive knowledge in the field of measurements and data analysis specific for the most demanding IC engines testing techniques - those related to engine working process analysis, emission and dynamic behaviour of its components.

### learning outcomes

Integration of knowledge on thermodynamics of an engine working process, heat and mass transfer, flows and state of the art measurements techniques and measuring chains for IC Engine indicating, exhaust emission measurement and engine dynamics measurement. PhD student trained for conducting and organising a research in the IC engine testing lab.

### theoretical teaching

- The importance of in-cylinder pressure measurement (indication in general)  
- Building pressure sensor and measuring chain  
- Thermodynamic relationships of engine working cycle parameters  
- Determining the piston TDC position  
- Data pretreatment, processing and analysis  
- Zero-point correction of the measurement data  
- Determination of residual gas proportion  
- Rapid evaluation methods  
- In-cylinder pressure indicating coupling with other rapid methods of measurement  
- Crankshaft instantaneous speed and acceleration measurements - torsional vibration analysis

### practical teaching

IC Engine test lab practice covering tasks incorporating in-cylinder pressure indicating, data processing and analysis; Practice on crankshaft torsional vibration measurement and data analysis; Practice with the Exhaust Emission test bench (NDIR, FID, Paramagnetic, Partial flow dilution tunnel,...);

### prerequisite

No particular requirements for attending this course

### learning resources

Mathworks Matlab/Simulink IDE (лиценца)  
AVL AST (Boost, Excite, Cruise)  
AVL CAMEO  
AVL Concerto
AVL Indicom
ETAS INCA
Fully equipped Engine test lab with AC dynamometer and Automation System.
Digital Acquisition system based on National Instruments Hardware and Software.
AVL Indimodul

**number of hours**

lectures: 35
research: 0

**assessment of knowledge (maximum number of points - 100)**

feedback during course study: 0
test/colloquium: 0
laboratory exercises: 50
calculation tasks: 0
seminar works: 20
project design: 0
final exam: 30
requirements to take the exam (number of points): 60

**references**

Manz: Indiziertechnik an Verbrennungsmotoren, TU Braunschweig
Kuratle, R., Motoren-Meßtechnik, Vogelverlag 1995
Fernando Puente León, Uwe Kiencke: Messtechnik: Systemtheorie für Ingenieure und Informatiker, Springer, 2011
Advanced Thermal Power Cycles

**ID:** PhD-3209  
**teaching professor:** Petrović V. Milan  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written

**goals**

1. The achievement of research and expert competence in the field of advance cycles in thermal power engineering.  
2. The achievement of high level of theoretical knowledge  
3. The acquisition of research and expert knowledge to optimize thermodynamic cycle (steam turbines cycles, gas turbine cycles, combined cycles).  
4. The achievement of the techniques of process modeling.  
5. Mastering the methods of experimental work in thermal power engineering.

**learning outcomes**

1. Expert and research deep knowledge of the thermodynamic cycle in thermal power engineering  
2. The development of critical thinking about energy use, fuel efficiency and environmental preservation  
3. The ability of calculate heat balance diagrams and main parameters of the steam turbine power plants.  
4. Ability to use computer technology for modeling and calculations

**theoretical teaching**


**practical teaching**

Development of method and computers code for design and optimization of thermal power cycles.

**prerequisite**

No preconditions

**learning resources**

Literature, computing facility, software

**number of hours**

lectures: 35  
research: 0
assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
-test/colloquium: 0
-laboratory exercises: 0
-calculation tasks: 20
-seminar works: 20
-project design: 0
-final exam: 50

requirements to take the exam (number of points): 15

references

Stojanovic, Thermal Turbomachinery, Gradjevinska knjiga, Belgrade, 1967.
Advanced Topics of Missile Guidance

ID: PhD-3509  
teaching professor: Todić N. Ivana  
level of studies: Ph.D. (doctoral) studies  
ECTS credits: 5  
final exam: seminar works

goals

This course is based on the application of the advanced concept in design of guidance laws. It is an extension and upgrade to the course Design of guidance, control and navigation systems.

learning outcomes

After this course the student is qualified for independent work on the synthesis of the guidance law and guidance systems as well as the necessary skills to participate in new developments in this field. The student acquires advanced knowledge in the field of guidance, navigation and control of missiles.

theoretical teaching

Introduction:  

practical teaching

The application and implementation of the guidance law on the case of homing missile.

prerequisite

None

learning resources


number of hours

lectures: 35  
research: 0

assessment of knowledge (maximum number of points - 100)
feedback during course study: 0  
test/colloquium: 0  
laboratory exercises: 20  
calculation tasks: 0  
seminar works: 40  
project design: 0  
final exam: 40  
requirements to take the exam (number of points): 40

references

0-471-94237-5, 1998
IEE Radar, Sonar, Navigation and Avionic Series 17, ISPB 0-86341-358-7, 2004
Cavage, P.G., ”Strapdown Inertial Navigation Integration Algorithm Design Part 2: Velocity
208-221
Landau, I.D., Lozano, R., M'Saad, M., Karimi, A., “Adaptive Control Algorithms, Analysis and
Advance fluid mechanics

**ID:** PhD-3441  
**teaching professor:** Crnojević Đ. Cvetko  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written+oral

**goals**

Bearing in mind that the basic fluid mechanics theoretical science that is the goal of the course is to familiarize students with the basic conservation laws: mass, momentum and energy, and to master some methods of solving problems of flow. Therefore, in the course of studying the different mathematical methods based on the analytical approach (if possible, developing solutions in order, various transformations, similar solutions, etc., From which it is possible to come up with a solution flow in some practical relatively simple cases, or geometries.

**learning outcomes**

As a result of the course of study of fluid mechanics is that PhD students are finding ways to correct application of equations and calculation methods. Due to the complexity of the basic system of equations describing the flow is essential that researchers in solving specific cases of flow, detect ways of simplifying the initial system of equations and assumptions under which it applies; then to recognize the possible application of some of the existing analytical or approximate methods, and to gain a general-higher level of knowledge to be able to interpret correctly the results of the calculation.

**theoretical teaching**


**practical teaching**

Introducing the relevant literature from fluid mechanics - books and scientific journals. Preparation of term papers from different areas of current research.
prerequisite

Expedient that students at undergraduate and graduate level courses listened basic fluid mechanics.

learning resources

From the fluid mechanics, for the purposes of gaining in-depth knowledge, there are a lot of good foreign books that are in the library of Mechanical Engineering, or available over the internet, so that the exchange rate is completely covered literature. To monitor rewarding achievements, it is necessary to use in libraries leading scientific journals: Fluid Mechanics, Physics of Fluid, and others.

number of hours

lectures: 35
research: 0

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 25
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 70
requirements to take the exam (number of points): 0

references

Chai-Shun Yih, (1979): Fluid Mechanics. West river press, Michigan, USA
Advance in Chemical Process Equipment

ID: PhD-3222
teaching professor: Radić B. Dejan
level of studies: Ph.D. (doctoral) studies
ECTS credits: 5
final exam: seminar works

goals

Mastering the method of modeling, development and design of chemical reactors and operations

learning outcomes

Getting to know the candidates with the problem and how to solve the problems of designing various types of chemical reactors that operate in different conditions. Introduction with types of chemical reactors. Setting up of mathematical models that can describe the processes in chemical reactors. Outcome: mastering the methodology of calculation of chemical reactors and chemical processes.

theoretical teaching


practical teaching

Students work under the supervision of teacher one seminar paper that needs student to apply knowledge. If needed laboratory work and visits to industrial facilities.

prerequisite

-

learning resources

Laboratory and computational equipment.

number of hours

lectures: 35
research: 0

assessment of knowledge (maximum number of points - 100)

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

references

Levenspiel, O.: Chemical reaction engineering (Serbian edition), Faculty of Technology and Mettalurgy, Belgrade, 1991.
Advances in drying processes and research

**ID:** PhD-3100  
**teaching professor:** Jovović M. Aleksandar  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** seminar works

**goals**

The aim of this course is introducing the candidates with problems and problem solving of drying, evaporation and wetting with appropriate scientific methods, subject is designed as an advanced course in the given area at level of doctoral studies.

**learning outcomes**

At the end of the course it is expected that the candidate has mastered the scientific knowledge pertaining to the analysis and evaluation of scientific papers, ways and methods of analysis of individual processes, laboratory work, as well as advanced process modeling in the area of the drying process, heat and mass transport in these processes and etc..

**theoretical teaching**


**practical teaching**

Laboratory work if needed or research at industrial installations.

**prerequisite**

There is no previous requirements for attending this course.

**learning resources**

Laboratory installation and measuring equipment if needed, measuring equipment for research at industrial installations.

**number of hours**

lectures: 35  
research: 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: 50
project design: 0
final exam: 50
requirements to take the exam (number of points): 0

references

ISBN 0 7506 4445 1
Papers from journals Drying, Journal of Colloid and Interface Science, Chemical Engineering Progress, Chemosphere i sl.
Advance techniques in IC engines – selected topics

ID: PhD-3423

**teaching professor:** Popović J. Slobodan

**level of studies:** Ph.D. (doctoral) studies

**ECTS credits:** 5

**final exam:** seminar works

**goals**

Acquiring new knowledge on role and importance of modelling dynamic processes in IC Engines. Broadening theoretical knowledge and analytical approach to thermodynamics, heat and mass transfer, fluid mechanics and fuel combustion by studying dynamic processes in IC Engine cylinder and collectors. Broadening knowledge and skills in applied computational methods and modular programming. Developing practical skills to design complex model structures and apply extensive and efficient numerical methods for studying and research of IC Engine dynamic processes.

**learning outcomes**


**theoretical teaching**

1. Selected topics in Engine exhaust and noise emission. Exhaust gas concentration modelling based on chemical reactions kinetics and chemical equilibrium. Exhaust gas emission measurement.
4. In-cylinder and port flow multidimensional modelling using CFD. The characterization of gas velocity profile in engine cylinders and ports by application of advanced anemometry measurement methods.

**practical teaching**

1. Chemical reactions kinetics and chemical equilibrium - Governing Equations and numerical solution. Laboratory test - IC engine exhaust emission measurement in steady state and transient operation conditions. Project task: Combustion product composition modelling based on assumption of chemical equilibrium
3. Engine mechanical losses modelling - Global models. Detailed empirical and analytic angle


prerequisite

Passed exam in Numerical methods and Advanced topics in IC engine simulation. Good practical knowledge of Matlab/Simulink

learning resources

Mathworks Matlab/Simulink IDE (Licensed)
Ricardo WAVE – 1D Engine and gas dynamics simulation software package (Licensed)
LMS Imagine.Lab AMESim – Simulation software for modelling and analysis of 1-D systems (Licensed)
Laboratories equipped with IC Engine testing equipment (fully equipped IC Engine test benches)
DAQ Measurement equipment (National Instruments PXI based system with LabView Development software)

number of hours

lectures: 35
research: 0

assessment of knowledge (maximum number of points - 100)

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

references
Aerodynamics and Flight Mechanics for Autopilot and Guidance System Design

ID: PhD-3508

teaching professor: Todić N. Ivana

level of studies: Ph.D. (doctoral) studies

ECTS credits: 5

final exam: project design

goals

The purpose of this course is to study all necessary performances of the missile required for the autopilot and guidance system design. The different reference trajectories are described and the following quantities are determined: missile velocity, trim angle of attack and control deflection, maximum lateral acceleration (maneuver capability), dynamic coefficients of the linearized perturbed motion and aerodynamic transfer functions parameters (natural frequency, relative damping ratio, factors of control and maneuver capability, incidence time lag constant, time constant of roll motion, factor of roll control effectiveness etc. Basic requirements for the autopilot design are discussed. The design of the autopilot for both statically stable and statically unstable missile is presented. The method of the design of the roll autopilot is also shown.

learning outcomes

Student is qualified for independent work on the preparation and analysis of data for the of autopilot synthesis and guidance law selection as well as a selection of system components.

theoretical teaching

Introduction:
Guidance and control of missile along trajectory. The role of aerodynamics in autopilot design. Subsystem relationships. How aerodynamics constrain autopilot performances. Statically stable and unstable configurations. Autopilot design for configurations with high maneuver capability.


practical teaching

Guided missile project, which includes the use of all fields enrolled within the contents of theoretical classes.

prerequisite

None

learning resources

Ćuk, D.: Lectures in course Missile guidance and control, Faculty of Mechanical Engineering,
Belgrade, 2002 (handouts)

**number of hours**

lectures: 35
research: 0

**assessment of knowledge (maximum number of points - 100)**

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

**references**

Aerodynamic Shape Optimization

ID: PhD-3015  
**teaching professor:** Bengin Č. Aleksandar  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** project design

**goals**

The aim of this course is to introduce students to the aerodynamic shape optimization that they can later use together with variety simulations of flows around aircraft and vehicles.

**learning outcomes**

During the course, the students will learn different steps in the aerodynamic shape optimization: how to make geometric parameterization of the model, how to perform the CFD simulations in design points and how to perform search for the optimal design (the optimization process).

**theoretical teaching**

Geometry parameterization; Meshing and mesh-movement methods; Flow solver efficiency and accuracy; Optimization techniques; Multi-disciplinary optimization; Optimization process chain; Verification and Validation.

**practical teaching**

Workshops with basic examples.

**prerequisite**

Knowledge of basic CFD and of C/C++ or FORTRAN languages is preferable.

**learning resources**

Linux cluster - SimLab. GNU C/C++ or GNU Fortran.

**number of hours**

lectures: 35  
research: 0

**assessment of knowledge (maximum number of points - 100)**

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

**ID:** PhD-3210  
**teaching professor:** Petrović V. Milan  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written

**goals**

1. The achievement of research and expert competence in the field of aerodynamic design of thermal turbomachinery.  
2. The achievement of high level of theoretical knowledge  
3. The acquisition of research and expert knowledge to optimize design of thermal turbomachinery.  
4. The achievement of the techniques of process modeling.  
5. Mastering the methods of experimental work in thermal power engineering.

**learning outcomes**

1. Expert and research deep knowledge in the field of aerodynamic design of thermal turbomachinery.  
2. The development of critical thinking about energy use, fuel efficiency and environmental preservation  
3. The ability of aerodynamic design of thermal turbomachinery.  
4. Ability to use computer technology for modeling and calculations  
5. Experimental methods in turbomachinery.

**theoretical teaching**

Systems of governing equations describing the flow of thermal turbomachines.  
Approximation in calculations of flow thermal turbomachinery. Loss and deviation models.  
Models of spanwise mixing and cooling. Models to determine properties of the working fluid.  
Numerical methods for solving of the system of equations for the flow calculation in thermal turbomachines.  
Experimental methods for measurements of flow in thermal turbomachinery.

**practical teaching**

Development of methodology and software for aerodynamic analysis and design of thermal turbomachinery.  
Experimental research.

**prerequisite**

PhD student - thermal power engineering.

**learning resources**

Computing facility, laboratory, measuring devices.

**number of hours**

lectures: 35
research: 0

**assessment of knowledge (maximum number of points - 100)**

feedback during course study: 10

test/colloquium: 0

laboratory exercises: 0

calculation tasks: 20

seminar works: 20

project design: 0

final exam: 50

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

**references**


Stojanovic, Themal Turbomachinery, Gradjevinska knjiga, Belgrade, 1967.


Krieger, 2004

Lakshninarajana, B: Fluid Dynamics and Heat Transfer of Turbomachinery, Wiley, 1996,
Aerodynamics of Turbocompressors

ID: PhD-3369
teaching professor: Petrović V. Milan
level of studies: Ph.D. (doctoral) studies
ECTS credits: 5
final exam: written

goals

1. The achievement of research and expert competence in the field of aerodynamics of compressors.
2. The achievement of high level of theoretical knowledge
3. The acquisition of research and expert knowledge aerodynamic design of compressors.
4. The achievement of the techniques of process modeling.
5. Mastering the methods of experimental work in thermal power engineering.

learning outcomes

1. Expert and research deep knowledge of aerodynamics of compressors.
2. The development of critical thinking about energy use, fuel efficiency and environmental preservation
3. The ability of calculate compressors.
4. Ability to use computer technology for modeling and calculations

theoretical teaching


practical teaching

Development of methodology and software for aerodynamic design of compressors.

prerequisite

PhD- student -thermal power enegineering

learning resources

Computing facility, literature

number of hours

lectures: 35
research: 0

assessment of knowledge (maximum number of points - 100)
feedback during course study: 10
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 20
seminar works: 20
project design: 0
final exam: 50
requirements to take the exam (number of points): 30

references

Stojanovic, Themal Turbomachinery, Gradjevinska knjiga, Belgrade, 1967.
Krieger, 2004
Lakshninarajana, B: Fluid Dynamics and Heat Transfer of Turbomachinery, Wiley, 1996,
Aero-hydrodynamics of Sailing Yachts

ID: PhD-3486

teaching professor: Kalajdžić D. Milan

level of studies: Ph.D. (doctoral) studies

ECTS credits: 5

final exam: written

goals

Aero-hydrodynamics of sailing yacht is not an important field of modern commercial shipbuilding, but it is very attractive and in it, due to advertising and other reasons, investing substantial resources. Students are not faced with this field, until the arrival of the doctoral studies. Subject Aero-hydrodynamics of sailing yachts to enable them to overcome the complex interaction aerodynamics of sails and hull hydrodynamics, and learn modern methods for the calculation speed of the sailing yacht depending on the strength and direction of wind.

learning outcomes

Candidate's ability to calculate motion of sailing yacht under the influence of constant wind (VPP), as well as solving the problem sailing yacht motion in gusting wind.

theoretical teaching


practical teaching

Numerical methods for solving differential equations coupled motion sailing yachts under the influence of gusting wind. Introduction with commercial software packages in this field, as well as software developed at the Department of Naval Architecture.

prerequisite

Completed master studies - Module of Naval Architecture

learning resources

Commercial software packages in this field, as well as software developed at the Department of Naval Architecture.

number of hours

lectures: 35
research: 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: 40
project design: 0
final exam: 50
requirements to take the exam (number of points): 40

references

Aeronautical Maintenance and Support

**ID:** PhD-3448  
**teaching professor:** Bengin Č. Aleksandar  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written

**goals**

Introducing students to the most advanced methods of logistics support airplanes in the world today. Also, teach students about the elements, such as maintainability, reliability, survivability and others, as constructive data of determining the efficiency of use of airplanes.

**learning outcomes**

Students will be introduced to the procedure of abstract thinking and creative idea generation, development methodology and the design of new aircraft to the optimal aeronautical support.

**theoretical teaching**


**practical teaching**

Factors the availability of elements (equipment): Self (internal) availability, achieved (reached) the availability, application availability, achieved availability. Development of computational tasks in the contents taught, activities in the prediction of maintainability, maintainability of aircraft structures, making computational tasks in the traversed material, Diagnostics - Nondestructive testing methods, modern concept of Aeronautical maintenance and support, combat survivability, vulnerability of aircraft and Consultation.

**prerequisite**

No special requirements

**learning resources**

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

**number of hours**

lectures: 35
research: 0

**assessment of knowledge (maximum number of points - 100)**

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

**references**

Aircraft Flight Dynamics

**ID:** PhD-3443  
**teaching professor:** Bengin Č. Aleksandar  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written

**goals**

Introducing students to the dynamics of atmospheric flight, orbital and interplanetary flight. Also, during this course in subjects like complex phenomena and dynamic stability and control of modern aircraft.

**learning outcomes**

Students will be introduced to the procedure of abstract thinking and creative idea generation, the methodology of the design and development of new aircraft and spacecraft on the most advanced technological solutions.

**theoretical teaching**


**practical teaching**

Modeling and Simulation of Flight path with MATLAB and Simulink. Simulation parameters of flight in wind tunnels.

**prerequisite**

No special conditions

**learning resources**


**number of hours**

lectures: 35  
research: 0
assessment of knowledge (maximum number of points - 100)

feedback during course study: 15

test/colloquium: 0

laboratory exercises: 0

calculation tasks: 0

seminar works: 45

project design: 0

final exam: 40

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

references
Aircraft Production Technology

ID: PhD-3450  
teaching professor: Bengin Č. Aleksandar  
level of studies: Ph.D. (doctoral) studies  
ECTS credits: 5  
final exam: written

goals

Introducing students to the most advanced aviation materials and technological processes that are used in the production of aircraft. Subjects like classic, composite, ceramic, hybrid, intelligent (smart) and functional materials and appropriate technology in the production of modern aircraft.

learning outcomes

Students will be introduced to the procedure of abstract thinking and creative idea generation, technological developments in the methodology of new aircraft that are designed and based on a completely new and modern technological solutions.

theoretical teaching


practical teaching

Verification, homologation and fatigue testing of aircraft structures that are performing at the Laboratory Institute of Aeronautical Department, Faculty of Mechanical Engineering, the University of Belgrade.

prerequisite

No special conditions.

learning resources

Books: A. A. Baker, Donald Kelly, Stuart Dutton, Alan A. Baker, Composite Materials for Aircraft Structures, 2nd Edition, AIAA, 2004, and Donald J. Leo, Engineering Analysis of Smart Material Systems, John Wiley & Sons, 2007, include necessary material for lectures, exercises, assignments, projects and term papers. Require additional materials (handouts, setting assignments, term papers, etc..) Are given at the web site or reproduced on paper. Large-scale electronic materials can be made available to students in direct contact. Laboratory of Aeronautical Department, Faculty of Mechanical Engineering, the University of Belgrade for verification, homologation and fatigue testing of aircraft structures.
number of hours

lectures: 35
research: 0

assessment of knowledge (maximum number of points - 100)

feedback during course study: 15
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 45
project design: 0
final exam: 40
requirements to take the exam (number of points): 40

references
Airfoils and Lifting Surfaces of Aircraft

ID: PhD-3446
teaching professor: Kostić A. Ivan
level of studies: Ph.D. (doctoral) studies
ECTS credits: 5
final exam: written

goals

The objective is to familiarize students with the geometric and aerodynamic characteristics of airfoils and lifting surfaces of aircraft, and specific characteristics of flow field and its modeling and optimizing around different types of airfoils and lifting surfaces at subsonic and supersonic speeds, using contemporary calculation methods and tools.

learning outcomes

After completing the course, the student will be able to understand and explain different aspects of correlations between airfoil shapes and their aerodynamic characteristics. Student will also acquire knowledge about rational selection, configuring and calculations of aerodynamic characteristics of lifting surfaces, depending on their application.

theoretical teaching

CFD modeling and analysis of aerodynamic characteristics of airfoils and lifting surfaces.

practical teaching

None.

prerequisite

None.

learning resources

Lectures in electronic form, flow simulation examples via the demo movies and clips, and graphical simulations available through the virtual workshop (program MOODLE), internet resources. Vlaero CFD software. Ansys FLUENT 14.
number of hours

lectures: 35
research: 0

assessment of knowledge (maximum number of points - 100)

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

references

I. Kostić, Z. Stefanović: Airfoils and Lifting Surfaces of Aircraft - handouts, University of Belgrade, Faculty of Mechanical Engineering, Belgrade, 2014.
Different NASA и AIAA technical reports and papers
Alternative vehicle drives

**ID:** PhD-3567  
**teaching professor:** Blagojević A. Ivan  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** seminar works

**goals**

The objective of the course is to get familiar with the classification, construction, operation and characteristic operating modes of alternative drives that can be used for moving vehicles. Alternative drives are applied in hybrid vehicles, electric vehicles that use batteries and fuel cell vehicles using hydrogen as a fuel. From ecological and energy point of view, their application is increasing, with advantages and disadvantages being considered by the course, including problems and effects of production, transport and price of electricity and hydrogen as propellant. The subject also analyzes various solutions of alternative drives in vehicles that are in use.

**learning outcomes**

Upon completion of this course, students should be trained to:
- identify alternative vehicle drives and identify its elements;
- explain how an alternative drives operate;
- analyze algorithms for operation and operating modes of alternative drives;
- analyze the energy and environmental effects of alternative drives in concrete examples;
- perceive the problems in the production and transport of energy for alternative drives.

**theoretical teaching**

Introductory lectures refer to the environmental and energy challenges related to an increasing number of motor vehicles and how these challenges can be overcome. Introductory lectures are followed by lectures on the classification of alternative drives (hybrid, electric with batteries and electric fuel cells) and a brief historical overview of development and use. For each of the alternative drives, the display of component elements and operating modes is given, as well as possible algorithms for managing them in different modes.

A special part relates to the consideration of different solutions for elements of alternative drives (electric motors, batteries, controllers, fuel cells), as well as examples of alternative drive vehicles.

A final chapter is the analysis of the effects of production and transport of electricity and hydrogen, as well as the accompanying logistics.

**practical teaching**

The content of practical teaching is in line with the research that the student is supposed to conduct.

**prerequisite**

**learning resources**

**number of hours**
lectures: 35
research: 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: 70
project design: 0
final exam: 30
requirements to take the exam (number of points): 40

references
Analitical mechanics

ID: PhD-3093

**teaching professor:** Jeremić M. Olivera

**level of studies:** Ph.D. (doctoral) studies

**ECTS credits:** 5

**final exam:** oral

**goals**

-to provide students knowledge of the fundamental principles and methods in Analytical Mechanics
-to enable students to solve practical problems in Analytical Mechanics using acquired knowledge in Analytical Mechanics
-to prepare students to monitoring novelties in science and engineering

**learning outcomes**

-to enable students to master terms, methods and principles in Analytical Mechanics
-to enable students to relate the knowledge from Analytical Mechanics with knowledge in other scientific fields, to apply knowledge from Analytical Mechanics in analysis, synthesis and prediction of solutions and consequences of problems in science

**theoretical teaching**


**practical teaching**


**prerequisite**

Defined by the curriculum study of Phd studies program.

**learning resources**

**number of hours**

lectures: 35
research: 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: 50
project design: 0
final exam: 50
requirements to take the exam (number of points): 30

**references**

Analogies of physical processes

**ID:** PhD-3442  
**teaching professor:** Ćočić S. Aleksandar  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written+oral

**goals**

The goal of the subject is to teach the student new knowledge from continuum mechanics and fluid mechanics, with main accent on analogies between various physical phenomena and processes.

**learning outcomes**

Student will gain new knowledge from areas of continuum mechanics and fluid mechanics, with main accent on analogies between various physical phenomena and processes.

**theoretical teaching**


**practical teaching**

Examples and solved problems which are accompanied the lectures.

**prerequisite**

Passed exams: Advanced mathematics (1.1.5), Numerical methods (1.2.5) and Selected topics from mechanics or fluid mechanics (2.1.5)

**learning resources**

**number of hours**

lectures: 35  
research: 0

**assessment of knowledge (maximum number of points - 100)**

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

references

Murphy, G., Shippy J., Luo, H: ENGINEERING ANALOGIES, Iowa State University Press, Ames
Laundau, Lifshitz, FLUID MECHANICS, Course in Theoretical Physics, Volume 6, Pergamon Press
S. Ananiev, ON ANALOGY BETWEEN TRANSITION TO TURBULENCE IN FLUIDS AND PLASTICITY IN FLUIDS, Turbulence, Heat and Mass Transfer 5
Analytical methods for engineering design

ID: PhD-3012

**teaching professor:** Babić R. Bojan

**level of studies:** Ph.D. (doctoral) studies

**ECTS credits:** 5

**final exam:** project design

**goals**

This course will enable the learner to appreciate that design involves synthesising parameters that will affect the design solution. The learner will prepare a design specification against a customer’s specific requirements. They will then prepare a design report that provides an analysis of possible design solutions, an evaluation of costs and an indication of how the proposed design meets the customer’s specification. It is expected that the learner will, during the design processes, make full use of appropriate information and communication technology.

Course aim is to scrutinize the design process in its entirety, from problem definition to conceptualization to embodiment and realization, in a discipline-independent framework, with the purpose of gaining insight into the process from the most general viewpoint.

**learning outcomes**

On successful completion of this unit a learner will:

1. Be able to prepare a design specification to meet customer requirements
2. Be able to analyse and evaluate possible design solutions and prepare a final design report
3. Understand how computer-based technology is used in the engineering design process.

**theoretical teaching**

Customer requirements: all relevant details of customer requirements are identified and listed; eg aesthetics, functions, performance, sustainability, cost, timing and production parameters; all relevant regulations, standards and guidelines are identified.

Design parameters: implications of specification parameters and resource requirements are identified and matched; the level of risk associated with each significant parameter is established.

Design information: all relevant information is extracted from appropriate reference sources; techniques and technologies used in similar products or processes are identified; use of new technologies are specified where appropriate; relevant standards and legislation are identified and applied throughout; design specification is checked against customer requirements.

**practical teaching**


**prerequisite**

Defined by curriculum of study programme/module.
learning resources

(1) I-TRIZ Innovation WorkBench – a comprehensive software tool for inventive problem solving.
(2) I-TRIZ Ideation Brainstorming – a simplified tool for solving problems of light to medium complexity.
(3) Axiomatic design software

number of hours

lectures: 35
research: 0

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, FLEXY-INTELLIGENT EXPERT SYSTEM FOR FMS DESIGN, Intelligent Manufacturing Systems Series, Book 5, University of Belgrade, Faculty of Mechanical Engineering, 1994, 18.1
Analytic Methods for Engineering Design

ID: PhD-3341  
teaching professor: Babić R. Bojan  
level of studies: Ph.D. (doctoral) studies  
ECTS credits: 5  
final exam: seminar works

goals

This course will enable the learner to appreciate that design involves synthesising parameters that will affect the design solution. The learner will prepare a design specification against a customer’s specific requirements. They will then prepare a design report that provides an analysis of possible design solutions, an evaluation of costs and an indication of how the proposed design meets the customer’s specification. It is expected that the learner will, during the design processes, make full use of appropriate information and communication technology.

Course aim is to scrutinize the design process in its entirety, from problem definition to conceptualization to embodiment and realization, in a discipline-independent framework, with the purpose of gaining insight into the process from the most general viewpoint.

learning outcomes

On successful completion of this unit a learner will:
1 Be able to prepare a design specification to meet customer requirements
2 Be able to analyse and evaluate possible design solutions and prepare a final design report
3 Understand how computer-based technology is used in the engineering design process.

theoretical teaching

Customer requirements: all relevant details of customer requirements are identified and listed eg aesthetics, functions, performance, sustainability, cost, timing and production parameters; all relevant regulations, standards and guidelines are identified
Design parameters: implications of specification parameters and resource requirements are identified and matched; the level of risk associated with each significant parameter is established
Design information: all relevant information is extracted from appropriate reference sources; techniques and technologies used in similar products or processes are identified; use of new technologies are specified where appropriate; relevant standards and legislation are identified and applied throughout; design specification is checked against customer requirements

practical teaching

Examples of application of analytic design methods. Axiomatic design of products, processes and systems. Application of axiomatic design in manufacturing domain. Defining functional requirements for manufacturing system. Design for manufacturing, design of manufacturing processes and intelligent machines. Intelligent system for design of manufacturing systems. Project and

prerequisite

Defined by curriculum of study programme/module.
learning resources

(1) I-TRIZ Innovation WorkBench – a comprehensive software tool for inventive problem solving.
(2) I-TRIZ Ideation Brainstorming – a simplified tool for solving problems of light to medium complexity.
(3) Axiomatic design software

number of hours

lectures: 35
research: 0

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, FLEXY–INTELLIGENT EXPERT SYSTEM FOR FMS DESIGN, Intelligent Manufacturing Systems Series, Book 5, University of Belgrade, Faculty of Mechanical Engineering, 1994, 18.1
Anisotropic plates and shells

**ID:** PhD-3013  
**teaching professor:** Balać M. Igor  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written+oral

**goals**

Main objective of the course is to teach students the fundamental principles of the mechanics of anisotropic plates and shells with emphasis on orthotropic plates. This theory is further applied to design and analyze unidirectional and multidirectional fiber orthotropic laminates. Within the course the basic issues associated with the design of anisotropic plates and shells will be studied as well. A special attention will be devoted to the practical stress and strain analysis of mechanical components made out of anisotropic plates and shells. Issues connected to the characterization of mechanical properties of composite materials will be tackled as well.

**learning outcomes**

1. Within the course students will learn various methods of the assessment of elastic constants entering into constitutive equations which describe mechanical behavior of anisotropic materials. The course will cover also the study of different failure criteria for various types of composite materials.
2. Students will learn how to perform stress–strain analysis of laminate composite materials.
3. The course will devote some attention to the influence of the environmental conditions (e.g. temperature and humidity) to the variation of mechanical properties of composite materials. This will be studied with a special focus on unidirectional and multidirectional composite laminates.
4. By completing this course students will become familiar with basic concepts of analyzing anisotropic plates and shells. A special attention will be devoted to the practical procedures of stress analysis of mechanical components made out of these materials, with numerical implementation of the most frequently used techniques.

**theoretical teaching**

1. Introduction to anisotropic materials: Basic concepts. Classification, main characteristics and the most frequent applications of anisotropic plates and shells in modern engineering. Orthotropic laminates.
practical teaching

1. Analytical examples of the assessment of macro mechanical properties of the orthotropic materials.
2. Examples of the Hooke’s law theory applied to the two dimensional unidirectional laminates. Determining of the stiffness matrix for these materials.
4. Numerical examples of determination of the ultimate strength using diverse failure criteria. Practical applications of failure theory to the ultimate strength calculations of mechanical components made out of orthotropic materials.
5. Examples of numerical implementations of diverse modeling techniques of orthotropic materials into the available codes. Comparison of numerical and analytical predictions of composite material component behavior.

prerequisite

Taken exams:
Strength of materials,
The base of strength of constructions.

learning resources

The whole course material is well covered by hand-outs written by the lecturers of the course. Every attendee of the course will be provided his/hers own copy of the hand-outs. Apart of this, all the below mentioned books can be borrowed from the lecturers during the course or ordered on some relevant websites.

number of hours

lectures: 35
research: 0

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 40
laboratory exercises: 0
calculation tasks: 5
seminar works: 20
project design: 0
final exam: 30
requirements to take the exam (number of points): 40

references

"Theory of plates and shells", S. Timoshenko, S. Woinowsky-Kreiger
"Theory of laminated plates", J.E. Ashton, J.M. Whitney
"Stresses in plates and shells” A. C. Ugural
"Elementary theory of elastic plates” L.G. Jaeger
Anisotropic plates” S.G. Leknitski
Application of Fracture Mechanics to Structural Integrity

**ID:** PhD-3248  
**teaching professor:** Sedmak S. Aleksandar  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** oral

**goals**

Course objectives are that students, after completing basic course in theory of fracture mechanics, and with their maximum involvement in practical training (through laboratory exercises, development of computational tasks, writing seminar papers, etc.), become competent in assessment of safety and integrity of structures. Students learn about possible practical applications of fracture mechanics based on a double-sided interpretation of its parameters, when setting up the fracture mechanics triangle provides an estimation of reliability structures. The practical application of fracture mechanics in order to prevent failure of real structures is analyzed. The potential cooperation with experts in the field of fracture mechanics is allowed, and through theoretical and practical training the appropriate academic skills are acquired, and they also develop specific creative and practical skills that are needed in professional practice.

**learning outcomes**

By attending this course, provided by the curriculum of the subject, the student will be able to solve particular problems of structural integrity, and to examine the possible consequences that may occur in case of bad solutions. By attending this course students will master the prediction techniques of residual strength of structures with cracks, fracture toughness testing techniques for metallic materials and welds. Students learn about issues involving analysis and diagnosis of behavior and lost of integrity, life assessment and rehabilitation of structures. It is anticipated to master weak spot prediction techniques in structural design, even before the appearance of cracks, as well as structural assessment when an error is detected using nondestructive testing methods. The student will also be able to link their knowledge in this field with other areas and apply them in practice.

**theoretical teaching**


**practical teaching**

Standard procedures for the fracture mechanics measurement, as material properties. Fracture diagram analysis and its application to welded joints and structures. Application of linear elastic fracture mechanics. Application of the leak principles before fracture design.

**prerequisite**

- 

**learning resources**

[1] Written lessons from lectures (handouts)
[7] Excerpts from the standard

**number of hours**

lectures: 35
research: 0

**assessment of knowledge (maximum number of points - 100)**

feedback during course study: 10

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

**references**

Artificial Intelligence & Machine Learning

ID: PhD-3353  
teaching professor: Miljković Đ. Zoran  
level of studies: Ph.D. (doctoral) studies  
ECTS credits: 5  
final exam: seminar works

goals

The main goal of Artificial Intelligence (AI) and Machine Learning (ML) is to program computers to use example data or past experience to solve a given problem. Many successful applications of machine learning exist already, including systems that analyze past sales data to predict customer behaviour (financial management), recognize faces or spoken speech, optimize robot behaviour so that a task can be completed using minimum resources, and extract knowledge from bioinformatics data, etc.

AI & ML presents an overview of basic AI methods for machine learning research.

The specific goals of this course follow:
• To provide historical context about AI, primarily over the 21st century;
• To enable PhD students to study a chosen specific AI methods such as artificial neural networks and genetic algorithms;
• To study the basic machine learning research in detail;
• To give PhD students insight into software tools for advanced simulation of artificial neural networks.

learning outcomes

AI and ML is a comprehensive course on the subject, covering topics not usually included in introductory machine learning. It discusses AI methods based in different fields, including artificial neural networks and genetic algorithms, signal and image processing, intelligent control, and data mining, in order to present a unified treatment of machine learning problems and solutions. All basic learning algorithms are explained so that the PhD student can easily move from the equations to a computer program, such as BPnet or Matlab.

theoretical teaching

After an introduction that defines machine learning and AI paradigms, the course covers clustering, decision tree induction, supervised learning (multilayer perceptrons), competitive learning (ART), reinforcement learning (Q-learning), intelligent agent interactions within an environment, and software tools for simulation of artificial neural networks (ANNs).

Main topics of the course are:
* What is Machine Learning?
* Artificial Intelligence – A Guide to Intelligent Systems (Fuzzy, ANNs, GA, etc.).
* Artificial Intelligence – Clustering; Decision Tree; Expert Systems.
* Supervised Learning; Competitive Learning; Reinforcement learning; etc.
* Artificial Neural Networks (ANNs) – Multilayer Perceptrons, ART, etc.
* Genetic Algorithms – Optimization.
* Reinforcement Learning Application (Q-learning) – The intelligent agent (Mobile robot) interacts with an environment (Empirical control).

practical teaching

Class activities consist of presentations and discussions (classroom & Moodle) as well as
computer simulation of neural networks - exercises based on BPnet and MATLAB software tools:
* Introduction to BPnet software – simulation of backpropagation neural net.
* Introduction to MATLAB software – neural network toolbox.
* Q-learning and Empirical control – intelligent mobile robot (Learning from Demonstration-LfD).
* Neural networks application – exercises to solve a given problem;
* Seminar paper assignment and explanations - Homework.
Homework consists of mandatory reading, study questions and research leading to a seminar paper with final presentation.

**prerequisite**

MSc degree of technically oriented faculty.

**learning resources**

[1] Software packages (BPnet, ART Simulator, MATLAB), Laboratory CeNT, University of Belgrade, Faculty of Mechanical Engineering, 18.13
[2] Laboratory mobile robot prototype (Khepera II mobile robot with gripper and camera; LEGO Mindstorms NXT and LEGO Mindstorms EV3 Sets of reconfigurable mobile robots equipped with sensors and microcontrollers), Laboratory CeNT, University of Belgrade, Faculty of Mechanical Engineering, 18.12

**number of hours**

lectures: 35
research: 0

**assessment of knowledge (maximum number of points - 100)**

feedback during course study: 15
test/colloquium: 0
laboratory exercises: 10
calculation tasks: 0
seminar works: 35
project design: 0
final exam: 40
requirements to take the exam (number of points): 40

**references**
Artificial Intelligence of Motor Vehicles

**ID:** PhD-3000  
**teaching professor:** Aleksendrić S. Dragan  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** seminar works

**goals**

The basic goal is research and development of scientific support aiming for improvement of motor vehicles performance on the level of their an intelligent and autonomous operation.

**learning outcomes**

Development of students’ abilities for conducting scientific research in the area of artificial intelligence of motor vehicles.

**theoretical teaching**

Lectures are based on consultation with students in accordance with the previously issued research tasks.

**practical teaching**

Practical lectures will be coordinated with the students research tasks.

**prerequisite**

There is no pre condition.

**learning resources**

Aleksendrić D., Ćirović V. Inteligentno kočenje,(knjiga u pripremi), 2015.  

**number of hours**

lectures: 35  
research: 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: 70
project design: 0
final exam: 30
requirements to take the exam (number of points): 0

references
Autonomous systems and machine learning

ID: PhD-3167
**teaching professor:** Miljković Đ. Zoran
**level of studies:** Ph.D. (doctoral) studies
**ECTS credits:** 5
**final exam:** seminar works

**goals**

Autonomous Systems (AS) include development of intelligent machines capable to fulfill working tasks in advanced manufacturing environment through hardware-software integration, without explicit human control. Considering the production technologies of the 21st century which include hardware-software integration of AS, especially robots, as well as automatic subsystems, this subject aims to qualify PhD students for independent development of modern manufacturing systems and processes, their modelling, until implementation of advanced technologies within the intelligent manufacturing systems based on theoretical and practical aspects of new algorithms and methods in domain of artificial intelligence.

**learning outcomes**

Starting from the fundamental concepts, this subject includes scientific multidisciplinary in accordance with biological inspired bases through perspective development realization in the fields of intelligent control, artificial life and application of autonomous systems in robotized production technologies of the 21st century. The outcome of this subject is oriented towards scientific progress of PhD students, especially through intensive scientific experimental research work in domain of hardware-software integration of AS within advanced technologies of the 21st century based on development of machine intelligence and learning (computational intelligence; machine Q-learning; advanced artificial intelligence techniques; Biological Manufacturing Systems (BMS), etc.).

**theoretical teaching**

Theoretical education is organized in several parts:
- Autonomous work and control of machine systems - Biologically inspired control of intelligent machines;
- Fundamental structural elements of AS - Sensor-actuator relation;
- Software architecture for autonomous systems - Hierarchical architecture; Reactive and behavioral architecture; Hybrid architecture; Open architecture;
- What is machine learning? - Nature of learning; Probabilistic approach to machine learning;
- Empirical control - Algorithm of empirical control; Application and influence of axiomatic design theory on empirical control development;
- Control of mobile robots family - Intelligent control of common mobile robot colony (ant colony optimization algorithms);

**practical teaching**

Practical education is organized in several parts:
- Localization and mapping of the manufacturing environment (laboratory work);
- Communicative and interactive competence of robots in working environment (laboratory work);
work);
• Machine learning and control (laboratory work);
• Robot learning (laboratory work); Evolutionary algorithms; Learning by Demonstration (LfD);
• Architecture of intelligent control of mobile robots (laboratory work); Heterogeneous robotic teams and cooperative work; Reconfigurability of mobile robots;
• Self-organizing, autonomous evolution and self-replication of robots.

prerequisite

MSc degree of technically oriented faculty.

learning resources

[1] Z. Miljković, D. Aleksendrić, ARTIFICIAL NEURAL NETWORKS – solved examples with theoretical background (2nd ed.), Textbook, University of Belgrade, Faculty of Mechanical Engineering, 2018, 18.1 /In Serbian/
[5] Laboratory mobile robot prototype (Khepera II mobile robot with gripper and camera; LEGO Mindstorms NXT and LEGO Mindstorms EV3 Sets of reconfigurable mobile robots equipped with sensors and microcontrollers), Laboratory CeNT, University of Belgrade, Faculty of Mechanical Engineering, 18.12
[6] Laboratory model of designed manufacturing system, Laboratory CeNT, University of Belgrade, Faculty of Mechanical Engineering, 18.12
[7] Software packages (BPnet, ART Simulator, MATLAB, AnyLogic, Flexy), Laboratory CeNT, University of Belgrade, Faculty of Mechanical Engineering, 18.13

number of hours

lectures: 35
research: 0

assessment of knowledge (maximum number of points - 100)

feedback during course study: 15
test/colloquium: 0
laboratory exercises: 15
calculation tasks: 0
seminar works: 30
project design: 0
final exam: 40
requirements to take the exam (number of points): 40

references


Basic Principles of Fracture Mechanics

**ID:** PhD-3247  
**teaching professor:** Sedmak S. Aleksandar  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** oral

**goals**

Course objectives are for the students to understand the basic principles of fracture mechanics theory. Introducing students to the application of fracture mechanics in the analysis of various engineering problems. Introducing students with analytical and experimental methods for the determination of fracture mechanics parameters. Analysis of damage and fracture mechanics using finite element method. The potential co-operation with experts in the field of materials science, which provides the ability to work in specialized laboratories.

**learning outcomes**

By attending this course students will master the basic principles in the field of fracture mechanics. Theoretical considerations and computational examples enable student to master all the necessary principles and standards in the field of fracture toughness tests of materials. Students master the methods of theoretical analysis and correlation of elasoplastic fracture mechanics, microstructural investigations and constitutive expression of continuum mechanics, in order to avoid fracture in metallic materials and their compounds. Introducing students to the existing modern standards and recommendations in the given field, using experimental tests.

**theoretical teaching**


**practical teaching**

prerequisite

-

learning resources

1] Written lessons from lectures (handouts)

number of hours

lectures: 35
research: 0

assessment of knowledge (maximum number of points - 100)

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

references

Biofluid mechanics – advanced course

ID: PhD-3266  
teaching professor: Stevanović D. Nevena  
level of studies: Ph.D. (doctoral) studies  
ECTS credits: 5  
final exam: seminar works

goals

The aim of this subject is getting knowledge about certain class of biological processes from the fluid mechanics point of view and introducing with scientific methods for predicting, analyzing and studying fluid dynamical processes in the human body.

learning outcomes

Students are qualifying for computing and analyzing by themself biofluid flow processes with contemporary and scientific methods. Also, they obtain the ability to apply these concepts appropriately for modeling biofluid flow in blood vessels, kidneys, lungs and joints.

theoretical teaching

Theoretical lessons incorporates: understanding of biofluid properties and applications of the fundamental laws (mass, momentum, and energy) that govern fluid mechanics to solve biofluid flow such as those in the cardiovascular system, introducing with basic non-Newtonian fluid models especially rheology of biofluids which are present in the human body, introducing with cardiovascular system and related diseases, circulatory system, steady and unsteady biological flows and wave propagation theory and oscillatory flow, defining velocity, pressure and flow rate in the blood vessels, modelling blood flow and diffusion process in kidneys, diffusion process in haemodialyser, blood and air flows in the lungs, joint friction, as well as modelling hydrodynamic separation of particles and cells, and hydrodynamic phenomena in drug-delivery systems.

practical teaching

Practical lessons contains applications of the basic fluid mechanics equations to solve biofluid flows such as: creating and solving mathematical models for blood vessels flow, solving models for stationary blood flow in rigid and elastic blood vessels, modeling pulsating fluid flow, calculation of the pressure wave propagation, calculation of the velocity, pressure and flow rate in blood vessels, modeling and calculating diffusion process among blood vessels walls and tissues and application on the haemodialysis process and renal flow.

prerequisite

Passed exams in Fluid Mechanics.

learning resources

Course handouts.

number of hours

lectures: 35
research: 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: 50
project design: 0
final exam: 40
requirements to take the exam (number of points): 50

**references**

Biologically Inspired Optimization Algorithms

**ID:** PhD-3529  
**teaching professor:** Petrović M. Milica  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** seminar works

**goals**

The aim of the course is to introduce students to the basic principles of biologically inspired optimization, as well as to provide them with theoretical and practical knowledge and skills so that they would be able to develop and implement optimization algorithms for solving engineering problems.

**learning outcomes**

After successfully completing this course, the students should be able to:
- formulate and mathematically model the optimization problem;
- understand all the phases necessary for algorithm implementation;
- implement the algorithm (the objective is to minimize/maximize the fitness function according to optimization criteria);
- develop their own codes in MATLAB environment and experimentally evaluate the performance of the algorithm;
- carry out scientific research work and apply biologically inspired algorithms to solve real optimization problems.

**theoretical teaching**


**practical teaching**

Research on biologically inspired optimization algorithms. Implementation of biologically inspired methods for solving practical optimization problems, depending on the candidate’s doctoral thesis. Laboratory work. Writing a seminar work. Publication of a research paper.

**prerequisite**

Completed technical college with basic programming knowledge in MATLAB environment.
learning resources

Laboratory for industrial robotics and artificial intelligence (ROBOTICS), Department for Production Engineering. MATLAB software, Laboratory CeNT, University of Belgrade - Faculty of Mechanical Engineering, Belgrade.

number of hours

lectures: 35
research: 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: 70
project design: 0
final exam: 30
requirements to take the exam (number of points): 50

references


**Boundary Layer Theory**

**ID:** PhD-3305  
**teaching professor:** Crnojević Đ. Cvetko  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** oral

**goals**

Basic theory of the boundary layer is studied in all basic courses Fluid Mechanics. However, this theory is very complex for both laminar and turbulent flow. The aim of the course is to investigate all relevant phenomena laminar and turbulent boundary layers starting from Prandtl to the present day.

**learning outcomes**

Outcome of the case is the knowledge of all the relevant phenomena of the boundary layer and mastery of balance equations of mass, momentum and energy with special applications to the study of the boundary layer. Special emphasis is on knowledge of specific mathematical methods applied for the calculation of the boundary layer.

**theoretical teaching**


**practical teaching**

Preparation of term papers of current areas of research.

**prerequisite**
No special requirements.

**learning resources**

**number of hours**

lectures: 35  
research: 0

**assessment of knowledge (maximum number of points - 100)**

feedback during course study: 12  
test/colloquium: 18  
laboratory exercises: 0  
calculation tasks: 0  
seminar works: 0  
project design: 0  
final exam: 70  
requirements to take the exam (number of points): 0

**references**

CAD/CAM Systems and Integration of Product and Manufacturing Design

ID: PhD-3400

**teaching professor:** Živanović T. Saša

**level of studies:** Ph.D. (doctoral) studies

**ECTS credits:** 5

**final exam:** project design

**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**

Upon successful completion of this course Students should be able to:

1. Application of acquired knowledge in the application of computers in the field of geometric modeling products.
2. Design technology of machine parts by using CAD / CAM system.
3. Integrate design products and technologies of their machining using the CAD / CAM system in the field of computer programming numerically controlled machine tools.
4. Know-how to program numerically controlled machine tools.
5. Prepare Technical Elaborate and reports about design products and technologies of their machining using the CAD / CAM system.

**theoretical teaching**

CAD/CAM systems, definitions, classifications. Learning resources.
Configurator for family product design.
CAD/CAM milling, grinding, EDM. CAD/CAM for multi-axis machining. Programming CNC machine tools by using CAD/CAM systems and machining parts on available machines.
Configuring the postprocessor in CAD/CAM system.
Configuring of virtual prototypes for the verification of the machining program and programming system using machining simulation in the CAD/CAM environment.
Integration of CAD/CAM system in the development of products using the STEP-NC.
CAD/CAM data exchange.

**practical teaching**

The course is designed to educate the participant with advanced technics of CAD/CAM user level as well as customization of these software tools. Each student is required to make at
least 3 projects in semester.

prerequisite

This course is strongly linked to the area of production engineering and there are no prerequisites for course attendance.

learning resources

1) CAD/CAM software package.
2) Test bed for the STEP-NC protocol based programming of CNC machines. STEP Tools: STEP-NC Machine, ST-Developer tools.
3) Functional simulator of the rapid prototyping machine tool.
4) Software for virtual machining system simulations
5) Test bed for configuring and programming of modular open architecture machine tools (MOMA).
6) Test bed for parallel kinematics machine tools.

number of hours

lectures: 35
research: 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: 70
final exam: 30
requirements to take the exam (number of points): 50

references

CAI model

ID: PhD-3560  
teaching professor: Stojadinović M. Slavenko  
level of studies: Ph.D. (doctoral) studies  
ECTS credits: 5  
final exam: seminar works

goals

Detailed study of metrological modeling techniques of products and development of new or improvement of the existing geometrically-technological-metrological model of products for the purpose of automatic inspection planning and measurement in production and everyday engineering practice. Generating knowledge for practical application and implementation on measuring machines of various producers by defining different control data lists and measurement protocols.

learning outcomes

After completing of the teaching process, the student own the necessary research and practical knowledge to understand and solve the metrological problems of integration of product design, of technology planning, of measurement and inspection planning. Automatic generation of measurement protocols and control data list for measuring machines of various manufacturers will ensure a reduction overall measurement time and inspection time and reduce measurement errors due to human factors. Also, the student will be able to effectively understand, researching, apply and improve engineering metrological problems and solve them with the concept of geometric-technological-metrological integration.

theoretical teaching


practical teaching

1. Geometric modeling of standard forms of tolerance for the complex metrological model of a product - a real product.  2. Taken parameters of metrological features from the STEP / IGES file.  3. Distribution of measuring points and generation of the initial measurement path.  4. Collision avoidance algorithm.  5. Optimization of the measurement path based on the ants colony - the final measurement path.  6. Generating measurement protocols and control data list.

prerequisite

MSc degree, primarily technical faculty.

learning resources

1. Handouts for each lecture.  2. The instruction for making seminar work.  3. The monograph in the field of quality and production metrology (in preparation).  4. Facility and technical
equipment: Laboratory for production metrology and TQM.

**number of hours**

lectures: 35  
research: 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: 60  
project design: 0  
final exam: 40  
requirements to take the exam (number of points): 50

**references**


CFD in Combustion

**ID:** PhD-3317  
**teaching professor:** Adžić M. Miroljub  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written

**goals**

Objective: The objective of this course is to provide students with methods and practice of CFD in combustion.

**learning outcomes**

Outcome: To encourage, teach and enable students to use the obtained knowledge of CFD in research and practice.

**theoretical teaching**

The aim of this course is to provide students with basic knowledge in CFD with chemical reactions and its application. Physical and chemical aspects of combustion, chemical kinetics and model reductions for typical fuels, combustion of solid, liquid droplets and gaseous fuels, will be included. Practical approaches through the use of ANSYS/FLUENT codes.

**practical teaching**

n/a

**prerequisite**

No preconditions to attend the classes.

**learning resources**

M. Adzie Handouts.
number of hours

lectures: 35
research: 0

assessment of knowledge (maximum number of points - 100)

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

references

Adžić M Handouts
Cognitive robotics

**ID:** PhD-3429
**teaching professor:** Miljković Đ. Zoran
**level of studies:** Ph.D. (doctoral) studies
**ECTS credits:** 5
**final exam:** seminar works

**goals**

The aim of the course is to provide students with a general overview of the cognitive robot development in order to achieve autonomous behaviour while solving the given task in real-world situations. Students will learn how to develop and implement machine learning based on computational intelligence AI techniques in order to achieve autonomous behaviour of the robot. In experimental process students will assess performance and accuracy of the developed model. The final outcome is to provide them with basics in cognitive capabilities of autonomous robots so as to enable them further research in this field.

**learning outcomes**

Expected learning outcomes are as follows:

- Selection of methods based on the application of artificial neural networks and other computational intelligence AI techniques in designing and building intelligence of cognitive robots;
- Implementation of developed algorithms in order to enable autonomous behaviour of mobile robots in laboratory model of manufacturing environment;
- Advanced programming in MATLAB® environment;
- Experimental verification of autonomous robot behaviour with analysis of experimental results and comparison with other existing methods;
- Building ability to analyze related work in the field of cognitive robotics;
- Team work.

**theoretical teaching**

Cognitive robotics – development of autonomous robot behaviour and its implementation in advanced technologies of the 21st century. Autonomous robots - machine learning from experience; learning from human teachers (Learning from Demonstrations-LfD); developing the ability to deal effectively with the real environment. Common elements and functions of autonomous robot:

- Machine vision
- Proximity sensing
- Anticipation and planning
- Programmable motion (mobility)
- Teachability
- Ability to learn from mistakes
- Long-term knowledge acquisition
- Ability to explore on its own, etc.

Empirical robot control. Implementation of machine learning and computational intelligence techniques in autonomous robotic systems with the primary goal to make the robot act and react appropriately in real-world situations (e.g. autonomous mobile robots can thus be observed interacting with their manufacturing environment based on long-term knowledge acquisition).
practical teaching


prerequisite

MSc degree of technically oriented faculty.

learning resources

2. Z. Miljković, Systems of artificial neural networks in production technologies (In Serbian), Series IMS, Vol. 8, University of Belgrade - Faculty of Mechanical Engineering, 2003
3. Laboratory mobile robot prototype (Khepera II mobile robot with gripper KheGrip and camera CMUcam VISION TURRET–KheCMUCam; LEGO Mindstorms NXT and LEGO Mindstorms EV3 Sets of reconfigurable mobile robots equipped with sensors and microcontrollers), Laboratory CeNT, University of Belgrade - Faculty of Mechanical Engineering.
4. Laboratory model of designed manufacturing system, Laboratory CeNT, University of Belgrade - Faculty of Mechanical Engineering.
5. Software packages (BPnet, ART Simulator, MATLAB®), Laboratory CeNT, University of Belgrade - Faculty of Mechanical Engineering.

number of hours

lectures: 35
research: 0

assessment of knowledge (maximum number of points - 100)

feedback during course study: 15
test/colloquium: 0
laboratory exercises: 15
calculation tasks: 0
seminar works: 30
project design: 0
final exam: 40
requirements to take the exam (number of points): 40

references
Combined Cycles with Gas Turbines & Steam Turbines

**ID:** PhD-3367  
**teaching professor:** Petrović V. Milan  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** oral

**goals**

1. The achievement of research and expert competence in combined cycles.
2. The achievement of high level of theoretical knowledge
3. The acquisition of research and expert knowledge to optimize combined cycles.
4. The achievement of the techniques of process modeling.
5. Mastering the methods of experimental work in thermal power engineering.

**learning outcomes**

1. Expert and research deep knowledge of the thermodynamic combined cycles in thermal power engineering
2. The development of critical thinking about energy use, fuel efficiency and environmental preservation
3. The ability of calculate heat balance combined cycles.
4. Ability to use computer technology for modeling and calculations

**theoretical teaching**

Project: Calculation of the heat balance of the CCGT plant. Optimization of the basic thermodynamic parameters.

**practical teaching**

Project: Calculation of the heat balance of the CCGT plant. Optimization of the basic thermodynamic parameters.

**prerequisite**

PhD student - thermal power engineering.

**learning resources**

Literature. Computing devices.

**number of hours**

lectures: 35  
research: 0

**assessment of knowledge (maximum number of points - 100)**
feedback during course study: 10

test/colloquium: 0

laboratory exercises: 0
calculation tasks: 20

seminar works: 20

project design: 0

final exam: 50

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

**references**


Stojanovic, Themal Turbomachinery, Gradjevinska knjiga, Belgrade, 1967.


Combustion Modeling

**ID:** PhD-3316  
**teaching professor:** Adžić M. Miroljub  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written

**goals**

Objective: The objective of this course is to provide students with methods and practice of mathematical modeling in combustion.

**learning outcomes**

Outcome: To encourage, teach and enable students to model combustion phenomena and use the obtained knowledge in research and practice.

**theoretical teaching**

The aim of this course is to teach students how to physically and mathematically model and use the knowledge in specific areas of combustion. The lectures cover basic elements of combustion, physical and mathematical modeling of mass, momentum, energy, chemical kinetics, use of reference coordinate systems, turbulence, averaging of differential equations, under steady and unsteady conditions, and combustion of solid, liquid and gaseous fuels.

**practical teaching**

n/a

**prerequisite**

No preconditions for attendance

**learning resources**

**number of hours**

lectures: 35  
research: 0

**assessment of knowledge (maximum number of points - 100)**

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

**references**
M. Adžić Handouts Combustion, D. Drasković, M. Radovanović and M. Adžić, Faculty of Mechanical Engineering Berlgrade
Competitive Manufacturing Management

ID: PhD-3392
teaching professor: Miljković Đ. Zoran
level of studies: Ph.D. (doctoral) studies
ECTS credits: 5
final exam: seminar works

goals

Competitive Manufacturing Management presents basic methods and new approaches for understanding the world of manufacturing, where every aspect of operations management must be highly responsive to customer needs.
The specific goals of this course follow:
• To show PhD students how to create and maintain valid and realistic master schedules;
• To study a practical guide to competitive manufacturing;
• To give PhD students insight into all important areas of a company within the framework of an effective master schedule.

learning outcomes

Master Scheduling (MS), as a part of Enterprise Resource Planning (ERP) and Supply Chain Management (SCM), is an essential planning process that helps manufacturing companies to synchronize their planned product supply with anticipated market demand.
This course includes the ideal guide for any PhD student (especially competitive manufacturing manager of the main board in the future work) who wants to avoid the most common mistakes while consistently maximizing the quality and performance of the optimal master schedule based on biologically inspired artificial intelligence techniques.

theoretical teaching

The course Competitive Manufacturing Management covers all the basic concepts as well as new approaches and explains how to create and manage a master scheduling system, perform rough-cut capacity planning and complete the planned process using finishing and final assembly techniques aimed at delivering the requested product to the customer in due time and in full.
Main topics of the course are:
* Competitive Manufacturing Management - Role and Scope.
* Chaos in Manufacturing; What is the Master Schedule - MS?
* The Mechanics of MS and Managing with the MS.
* Master Production Scheduling (MPS) & Advanced Techniques of Optimization - Biologically inspired algorithms of optimization.
* Using MPS Output in a Make-to-Order Environment.
* Master Scheduling in Customer-Product Environments.

practical teaching

Other relevant topics (exercises to solve a given problem) covered include scheduling in discrete as well as flow environments, warranty decisions, demand and supply management, sales and operations planning and effective implementation:
* Sales, Operations Planning and Rough-Cut Capacity Planning.
* Product Warranty and Manufacturing; Warranty Decisions.
* Supply, Demand and Warranty Management.
* Optimization and Effective Implementation.

**prerequisite**

MSc degree of technically oriented faculty.

**learning resources**

[1] Software packages (BPnet, ART Simulator, MATLAB), Laboratory CeNT, University of Belgrade, Faculty of Mechanical Engineering, 18.13

**number of hours**

lectures: 35  
research: 0

**assessment of knowledge (maximum number of points - 100)**

feedback during course study: 15  
test/colloquium: 0  
laboratory exercises: 10  
calculation tasks: 0  
seminar works: 35  
project design: 0  
final exam: 40  
requirements to take the exam (number of points): 40

**references**

Composite Materials Mechanics

**ID:** PhD-3514  
**teaching professor:** Balać M. Igor  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written

**goals**

Main objective of the course is to teach students the fundamental principles of the mechanics of composite materials. This theory is further applied to design and analyze unidirectional and multidirectional fiber composite laminates. Within the course the basic issues associated with the design of composite materials will be studied as well. A special attention will be devoted to the practical stress and strain analysis of mechanical components made out of composite materials. Issues connected to the characterization of mechanical properties of composite materials will be tackled as well.

**learning outcomes**

1. Within the course students will learn various methods of the assessment of elastic constants entering into constitutive equations which describe mechanical behavior of composite materials. Problems of determination of macro behavior of composite materials starting from known properties of components entering into it will be tackled as well. The course will cover also the study of different failure criteria for various types of composite materials.  
2. Students will learn how to perform stress – strain analysis of laminate composite materials.  
3. The course will devote some attention to the influence of the environmental conditions (e.g. temperature and humidity) to the variation of mechanical properties of composite materials. This will be studied with a special focus on unidirectional and multidirectional composite laminates.  
4. By completing this course students will become familiar with basic concepts of mechanics of composite materials. A special attention will be devoted to the practical procedures of stress analysis of mechanical components made out of composite materials, with numerical implementation of the most frequently used techniques.

**theoretical teaching**

1. Introduction to composite materials: Basic concepts. Classification, main characteristics and the most frequent applications of composite materials in modern engineering.  
practical teaching

1. Analytical examples of the assessment of macro mechanical properties of the composite materials.
2. Examples of the Hooke’s law theory applied to the two dimensional unidirectional laminates. Determining of the stiffness matrix for the composite material.
4. Numerical examples of determination of the ultimate strength using diverse failure criteria. Practical applications of failure theory to the ultimate strength calculations of mechanical components made out of composite materials.
5. Examples of numerical implementations of diverse modeling techniques of composite materials into the available codes. Comparison of numerical and analytical predictions of composite material component behavior.

prerequisite

Taken exams:
Strength of materials,
The base of strength of constructions.

learning resources

The whole course material is well covered by hand-outs written by the lecturers of the course. Every attendee of the course will be provided his/hers own copy of the hand-outs. Apart of this, all the below mentioned books can be borrowed from the lecturers during the course or ordered on some relevant websites.

number of hours

lectures: 35
research: 0

assessment of knowledge (maximum number of points - 100)

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

references

"Mechanics of composite materials", Autar K. Kaw
"Principles of composite materials mechanics", Ronald F. Gibson
"Mechanics of Elastic Composites", Nicolaie Dan Cristescu, Eduard-Marius Craciun and Eugen Soós
"Mechanics of Composite Materials with MATLAB" George Z. Voyiadjis and Peter I. Kattan
"Mechanics of composite materials", Robert M. Jones
Computational Fluid Dynamics

**ID:** PhD-3557  
**teaching professor:** Simonović M. Aleksandar  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written

**goals**

Educate students to understand foundations of fluid flow simulations and develop ability to design simulation software.

**learning outcomes**

Ability to design and control density of computational grids. Ability to express physical laws in generalized curvilinear coordinate system. Ability to transfer governing equations and boundary conditions from physical to computational space. Ability to solve incompressible low Reynolds number Navier-Stokes Equations. Ability to apply turbulence modelling in fluid flow simulations. Ability to solve Euler equations of motion.

**theoretical teaching**


**practical teaching**

Each theoretical topic is illustrated with multiple examples which illustrate solution procedure and the procedure of the presentation of results.

**prerequisite**

**learning resources**

Computer laboratory, laptop, projector

**number of hours**

lectures: 35  
research: 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: 0  
project design: 60  
final exam: 30  
requirements to take the exam (number of points): 40
references

Klaus Hoffmann, "Computational Fluid Dynamics for Engineeris", Engineering Education System, Austin
Computational fluid dynamics of buildings and vehicles

**ID:** PhD-3506  
**teaching professor:** Simonović M. Aleksandar  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written

**goals**

The course deals with problems of fluid flow around buildings and road and rail vehicles. The goal of this course is to introduce students to the influences that atmospheric flows have on objects in terms of loading and the impact of the flow around the vehicle on vehicle performance. Determination of wind loads on buildings, bridges and other structures have a large influence on the design and sizing of structural elements. The student becomes familiar with the numerical calculation of flow around objects, solve practical problems and compares the results with the recommendations in the industry standards. Large development of automobile industry caused a large amount of research in the field of aerodynamics in order to improve vehicle performance and vehicle efficiency. Learning about the theoretical foundations of aerodynamics in parallel with the techniques of numerical calculations that are used in the determination of the aerodynamic forces on the vehicle as well as the influence of these forces on the performance and efficiency of the vehicle the student acquires a global view of the problem of vehicle aerodynamics and the ways in which they can be solved.

**learning outcomes**

After passing the course, students gain practical and theoretical knowledge that will serve as a basis for further research and practical work. By adopting the exposed material the student is able to independently deal with the problems of aerodynamics of buildings and vehicles and to use simple numerical techniques for solving them. While solving course assignments students are trained to use modern software tools and to develop and solve simple mathematical models with their own computer code.

**theoretical teaching**

Introduction, Basis of fluid mechanics, Wind in the atmosphere, Wind forces, Static wind load on buildings and structures, Dynamic wind load on buildings and structures, Basics of numerical simulation of problems in fluid mechanics  
Importance of vehicle aerodynamics and aerodynamic forces, Ground effects, Drag and efficiency, Noise, Numerical methods and use of Computational Fluid Dynamics (CFD), Wind-tunnels

**practical teaching**

Solving of problems of building and vehicle aerodynamics by numerical methods, Exercises in aerodynamics of road vehicles, Exercises in rail vehicle aerodynamics, Exercises in aerodynamics of building and structures, Introduction to the regulations and standards in the field of aerodynamics of building and structures, Visit to the wind tunnel

**prerequisite**

There is no necessary requirement for attendance of computational fluid dynamics of
buildings and vehicles

**learning resources**

Simlab - computer laboratory

**number of hours**

lectures: 35
research: 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: 70
project design: 0
final exam: 30
requirements to take the exam (number of points): 0

**references**

Petrovic Z, Stupar S, CFD one, Faculty of Mechanical Engineering, 1992
Selected research articles and conference papers.
Additional materials (lecture hand-writings, problem settings, task solving guidelines)
Computational Fracture Mechanics

ID: PhD-3249  
teaching professor: Sedmak S. Aleksandar  
level of studies: Ph.D. (doctoral) studies  
ECTS credits: 5  
final exam: oral

goals

Introduce students to the possibilities of numerical methods application to problems of fracture mechanics. Introducing students to the application of finite element method in the analysis of nonlinear problems. Understanding and studying the problems of coupled external loads on welded structures. The development of an independent and practical work using licensed software.

learning outcomes

By attending this course the student will master advanced application of finite element method, especially in the field of welding and welded structures. The importance of the application of computational fracture mechanics to structures when there are already noted one or more of the initial cracks. Students are trained to use computational methods to determine whether the stress fields on the constructions will lead to further growth of the crack, and whether crack will be stable or unstable, and based on that can determine the remaining life of the structure. Theoretical considerations, computational exercises and work with the licensed software, will allow students to synergize the previously acquired knowledge of mathematics, mechanics, structures integrity and mechanical materials, and apply this knowledge in engineering practice.

theoretical teaching


practical teaching

Determination of fracture mechanics parameters in elastic and elastic-plastic field. Experimental, numerical and analytical methods. Application of various algorithms in solving nonlinear problems; the accuracy and convergence of the solutions. Examples of FEM formulation of nonlinearities of geometry. Developments of FEM contact models. FEM

**prerequisite**

-  

**learning resources**

[1] Written lessons from lectures (handouts)

**number of hours**

lectures: 35  
research: 0

**assessment of knowledge (maximum number of points - 100)**

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

**references**

Computational Modeling in Mechanical Engineering

**ID:** PhD-3017  
**teaching professor:** Bengin Č. Aleksandar  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** project design

**goals**

The purpose of this course is to provide students with the tools required for computational design and modeling for mechanical engineering applications.

**learning outcomes**

Mastering the course, the student acquires knowledge of the entire computational modeling process, from the formulation of a qualitative model, to its quantitative formulation, to model fitting and validation, model analysis, and model predictions. The students will gain skills in the various computational methods that can be employed for modeling and especially on the advantages (and disadvantages) of each approach.

**theoretical teaching**

Computational modeling: generalities. Computational geometry and application to mechanical systems modeling. Finite element, finite difference computational fluid dynamic modeling.

**practical teaching**

Workshops with basic examples.

**prerequisite**

Knowledge of C/C++ or FORTRAN languages is preferable.

**learning resources**

Linux cluster. GNU C/C++ or GNU Fortran.

**number of hours**

lectures: 35  
research: 0

**assessment of knowledge (maximum number of points - 100)**

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

ID: PhD-3265

teaching professor: Stevanović D. Vladimir

level of studies: Ph.D. (doctoral) studies

ECTS credits: 5

final exam: written

goals

The aim of the subject is developing skills for the simulation and analyses of multiphase flows in complex geometries of components in energy plants.

learning outcomes

Students are trained to develop mathematical models of multidimensional multiphase flows, to solve these models with computational multi-fluid dynamic methods and to conduct simulation and analyses with the aim of designing and analyzing the operation of equipment of complex geometry in energy plants.

theoretical teaching


practical teaching

Computer simulations of boiling two-phase flows in steam generators and heat exchangers.

prerequisite

Attended courses in Fluid Mechanics, Thermodynamics and Numerical methods within maser or doctoral studies.

learning resources

Course handouts.

Computer equipment.
Software for numerical solving of systems of differential equations of various types.
Software for simulation and analyses of pressure transients in pipeline networks and pressurized vessels.
Software for simulation and analyses of multidimensional two-phase flows.

number of hours

lectures: 35
research: 0

assessment of knowledge (maximum number of points - 100)
feedback during course study: 30
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 40
project design: 0
final exam: 30
requirements to take the exam (number of points): 0

references

Stevanovic, V., Thermal-Hydraulics of Steam Generators – Modelling and Numerical Simulation, University of Belgrade, Faculty of Mechanical Engineering, 2006.
Computation Theory

**ID:** PhD-3225  
**teaching professor:** Radojević LJ. Slobodan  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written+oral

**goals**

The acquisition of basic knowledge of the Theory of computation.

**learning outcomes**

Upon completion of the course, a PhD student understands the concepts of the Theory of computation. Understand the concept of formal and informal algorithms and concepts decidable and undecidable problems and their role in Computer Science.

**theoretical teaching**

1. Turing machine.  
2. UR machines.  
3. Primitive recursive functions, recursive functions.  
4. Enumeration, universal functions.  
5. Decidability, undecidability, partial decidability.  
6. Recursive and recursively numbered sets.  
7. Simplify and degree of speed.  
8. Recursion theorem.

**practical teaching**

Follow theoretical teaching.

**prerequisite**

Programming and C or C++.

**learning resources**

Blackboard and chalk.

**number of hours**

- lectures: 35  
- research: 0

**assessment of knowledge (maximum number of points - 100)**

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

references

Computer Based Measurements

**ID:** PhD-3425  
**teaching professor:** Miljić L. Nenad  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** project design

**goals**

The aim of the course is to provide comprehensive insight into the digital acquisition systems (DAQ), measurement systems and, mainly, their usage in the field of testing of systems covered in the Mechanical Engineering; To introduce students the world of virtual instrumentation and graphical programming environment (LabVIEW) which is dedicated to development of DAQ applications. To gain experience on functioning and using DAQ systems through numerous, real world, examples. To get closer acquaintance with the sensors, and digital acquisition software & hardware, in general, and methods of DAQ software developing and testing.

This course is, mainly, intended for students not closely familiar with the computer based measurement techniques at level needed for PHD studies, as well for those who are willing to extend their knowledge in this area.

**learning outcomes**

Ability to integrate sensors and DAQ hardware in measurement chain in order to fulfill specific requirements in the field of mechanical engineering system testing & measurements. Ability to build and test software application (LabVIEW virtual instruments) for measurement and automation of various mechanical engineering systems. Practical knowledge in computer based measurements of fundamental engineering data.

**theoretical teaching**

Architecture and basic principles of data acquisitions systems (DAQS); Definition and clarification of the fundamental terms in the field of measurement technique. Fundamentals of signal filtering (Analog & Digital); Hardware components of the DAQ module – DAQ device; Basic principles of digital data acquisition; DAQ based measurement chains for the measurement of a temperatures, pressures, forces, torques, speed, acceleration,...; Specific issues on digital input/output of DAQ devices; Counters and their usage for counting of discrete events and position measurement; Communications standards in measurement instrumentation (RS-232, RS-422/485, IEEE-488 (GPIB));

**practical teaching**

Introduction to the Virtual Instrumentation (VI) and LabVIEW development environment; Data flow in VI; Troubleshooting and Debugging Vis; Implementing a VI; Managing Hardware resources (Low and High-Level File I/O ); Common Design Techniques and Patterns; Synchronization Techniques; Event Programming; Error Handling; Controlling the User Interface ( VI Server Architecture; Control references); File I/O Techniques ; Improving an Existing VI; Creating and Distributing Applications; Student Project: Building a DAQ with given requirements;

*)National Instruments (NI) Labview courses “Core 1” & “Core 2” are incorporated in the
theoretical and practical teaching of this course. This course is in compliance with the “LabVIEW Academia” program and therefore offers students all benefits stated in LabVIEW Academia agreement.

**prerequisite**

No particular requirements for attending this course

**learning resources**

Handouts: N. Miljić, Computer Based Measurements & Virtual Instrumentation
DACQs: National Instruments USB 6008, MyDAQ, PXI, ...
Graphical Development Environment: National Instruments LabView 2010 with modules and toolkits (LVA package)
Auxiliary platforms: Demo board for simulation of analog and digital signals; Universal Amplifying / Conditioning board for various sensors; Driver board for DC and step motors

**number of hours**

lectures: 35
research: 0

**assessment of knowledge (maximum number of points - 100)**

feedback during course study: 0
test/colloquium: 0
laboratory exercises: 25
calculation tasks: 0
seminar works: 0
project design: 45
final exam: 30
requirements to take the exam (number of points): 60

**references**

Labview Core 1 & 2 Course Manual & Exercises, National Instruments
Robert H. King:Introduction to Data Acquisition with LabVIEW,McGraw-Hill,2009,
Fernando Puente León, Uwe Kiencke:Messtechnik: Systemtheorie für Ingenieure und Informatiker, Springer, 2011
Computer modeling and structure calculation

**ID:** PhD-3571  
**teaching professor:** Milošević-Mitić O. Vesna  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** seminar works

**goals**

Mastering of the Computer modeling and structure calculation and an active work on the computer. Modeling and calculation of complex structures and problems. Determination of displacements and stresses. Reliable prediction of structural response and determination the cause of bad behavior, yielding and damage of structure. Static, thermal and dynamic analysis.

**learning outcomes**

The course provides skills to acquisition modeling and design of structures using computers and Finite Element Method. This allows solving the real problems of structural strength in its service life. Mastering the course will enable the application on different areas and active work on the computer using finite element method.

**theoretical teaching**


**practical teaching**


**prerequisite**

No condition

**learning resources**

1. KOMIPS - a software package for the calculation of structures - ICT – IAS

**number of hours**

lectures: 35
research: 0

assessment of knowledge (maximum number of points - 100)

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

references

T. Maneski, Computer modeling and calculation of structures, Faculty of Mechanical Engineering, 1988
T. Maneski, V.Milošević-Mitic, D. Oštrić, The statement of structural strength, Faculty of Mechanical Engineering, Belgrade, 2000
T. Maneski, Resolved problems of structural strength, faculty of Mechanical Engineering, Belgrade, 2000
Contemporary Trends in Ship Structural Design

**ID:** PhD-3189  
**teaching professor:** Motok D. Milorad  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** seminar works

**goals**

Explanation of reasons for significant changes of hull structure concept of some types of contemporary ships - mainly tankers, bulk carriers and container ships. Studying the influence of those changes on strength calculations and determination of hull structure scantlings.

**learning outcomes**

Student becomes capable of conducting calculations and procedures for contemporary ships' hull structure scantling definition.

**theoretical teaching**


**practical teaching**

Studying Classification societies' rules on above topics.

**prerequisite**

Defined by the curriculum of the studies.

**learning resources**

Classification societies' rules on above topics.

**number of hours**

- lectures: 35  
- research: 0

**assessment of knowledge (maximum number of points - 100)**

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

**references**
Continuum Mechanics

ID: PhD-3405
teaching professor: Mladenović S. Nikola
level of studies: Ph.D. (doctoral) studies
ECTS credits: 5
final exam: written

goals

-to introduce students contemporary problems of Continuum Mechanics as the basis of separated area of Mechanics such as Theory of Elasticity, Thermoelasticity, Theory of Plasticity, Fluid Mechanics, Strength of Materials
-to introduce students to the specially mathematical methods which are constitutive parts of the Continuum Mechanics such as Tensor Calculus, Differential Geometry, Computational and Numerical Methods

learning outcomes

From theoretical point of view, Continuum Mechanics are dealing with mathematical models of real bodies. In that way it can be get to the exact formulation of corresponding physical laws of considered body behavior as reaction under mechanical, therimaical, electromagnetical and chemical effects. This is important for application of reached knowledge in engineering practice.

theoretical teaching


practical teaching

-

prerequisite

Defined by the curriculum study of Phd studies program.

learning resources


number of hours

141
lectures: 35
research: 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: 50
project design: 0
final exam: 50
requirements to take the exam (number of points): 30

**references**

Cutting Theory

**ID:** PhD-3284  
**teaching professor:** Tanović M. Ljubodrag  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written

**goals**

Theoretical considerations of the cutting process and its phenomena, establishing the regularities of the process as a prerequisite for solving the problems of manufacturing engineering. Establishing the logic of theoretical modeling of the cutting process, systemic approach to problem solving, analysis of diverse aspects of viewing the problem and practical application of theoretical elaborations.

**learning outcomes**

The student should acquire knowledge and develop skills needed for advanced critical and self-critical approach to cutting theory.  
Solving of concrete problems by using scientific methods and procedures.

**theoretical teaching**

Basics of the theory of cutting, Tool materials (Tool steels, hard metals, tool ceramics, CTM), Tool geometry and cutting layer elements (chip thickness and width), Kinematics of cutting, Chip formation (chip compression, deposits on the cutting edge, chip forms and quality of surface finish), Cutting forces (dynamometry, modeling and cutting strength), Heat and temperature in the cutting zone (heat balance and measurement), Cutting tools wear, Cutting modes in machining by turning, drilling, milling, planing, grinding and broaching of contemporary construction materials.

**practical teaching**

Practical teaching involves laboratory work in Laboratory for machine tools and machining systems, and seminar work writing. Planned experiments are carried out in the Laboratory with finishing the reports. These reports are a part of the seminar work.

**prerequisite**

MSc degree, preferably in technical sciences

**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**

lectures: 35  
research: 0

**assessment of knowledge (maximum number of points - 100)**
feedback during course study: 0
test/colloquium: 0
laboratory exercises: 40
calculation tasks: 0
seminar works: 30
project design: 0
final exam: 30
requirements to take the exam (number of points): 0

references

Decision Theory

ID: PhD-3169

teaching professor: Misita Ž. Mirjana

level of studies: Ph.D. (doctoral) studies

ECTS credits: 5

final exam: oral

goals

This PhD-level course on decision theory focuses on theories of individual and group
decision making under risk and uncertainty. The course briefly explores utility theory under
certainty and the notion of preferences and their representation, then progresses to the
classic theories of decision under risk and uncertainty. Application Decision support Systems,
Expert Systems, Knowledge-based systems in process of managerial decision making.

learning outcomes

Upon successful completion of this course, students should be able to:
- Formulate and design a model the complex problem of decision-making,
- Decompose a complex problem of decision-making,
- Identify a method to solving each decomposed part of a complex decision-making problem,
- Solve the complex problem of decision-making, independently or with the assistance of a
adequate software tool for decision-making.

theoretical teaching

The course consists of three major sections: 1) modeling decisions, where the emphasis is on
structuring decision problems using techniques such as influence diagrams and decision
trees; 2) modeling uncertainty, which covers subjective probability assessment, the use of
classical probability models, Bayesian analysis, and value of information; and 3) modeling
preferences, which introduces the concepts of risk preference, expected utility, and multi-
attribute value and utility models.

practical teaching

Design knowledge-based system for problem defined in doctoral thesis methodology.

prerequisite

Enrolled 1st semester of doctoral studies.

learning resources

On-line free academic access to electronic databases: ebesco, science-direct, emerald, etc.
Computer classroom. Real practical example in pilot factory - access to real data and database
in for purpose of solving real practical complex managerial problems.

number of hours

lectures: 35
research: 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: 10
project design: 30
final exam: 50
requirements to take the exam (number of points): 30

references

Design of Aerospace Structures

**ID:** PhD-3456  
**teaching professor:** Grbović M. Aleksandar  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written  

**goals**

To provide background and experience in issues associated with structural design: failure criteria (fatigue, fracture, buckling, corrosion, etc.), design constraints, loads, materials selection, manufacturing issues, joints & assembly methods, stress analysis and nondestructive inspections. Also, to provide opportunities to develop skills needed for the successful designer: training in CATIA’s modules Wireframe and Surface Design, Aerospace Sheet Metal Design, Kinematics and Generative Structural Analysis is an integral part of this course.

**learning outcomes**

Design of Aerospace Structures is a course for students who wish to expand their 3D-CAD skills and to continue with professional development in a mechanical design related field. By completing this course students will be able to create simple and complex surfaces necessary for successful aerospace design, as well as to create sheet metal parts within CATIA v5 environment. Also, they will acquire skills necessary for checking the design in CATIA’s modules for kinematics and FE analysis.  
During this course, participants will have opportunities to develop other skills needed for the successful designer: technical communications (oral and written), technology assessment & transition, teamwork issues, creativity & problem solving techniques, engineering ethics.

**theoretical teaching**

1. Nature of design process: review stress-strain behavior and stress/displacement formulae

2. Design Constraints (loads): overview failure criteria (elastic deformations, yield, creep, corrosion, fatigue, fracture); other design constraints (weight, costs, performance, etc.)

3. Mechanical Joints overview: welds, bonded joints and fasteners; attachment lugs; load transfer/stress analysis issues

4. Manufacturing Issues: dimensioning, tolerances, overview of manufacturing methods

5. Damage Tolerant Design: Introduction to linear elastic fracture mechanics (fracture toughness, fatigue crack growth), damage tolerant design criteria.

6. Corrosion prevention

7. Fatigue: overview of stress and strain life concepts for prediction fatigue crack formation, fatigue improvement processes

8. Overview of aerospace materials
9. Buckling: columns, plates, local crippling

10. Non destructive inspection

11. Case histories of component failures and design deficiencies

12. Lessons learned in aircraft design: the lessons drawn from the aircraft accident/incident literature

**practical teaching**

1. Basic Wireframe Geometry Introduction:
   Wireframe Geometry Overview; Work on Support; Creating Reference Points, Lines and Planes; Axis Creation, Wireframe Circle and Corner Creation; Reference Features.

2. Spline Creation and Editing:
   Spline Terminology; Spline Creation in Sketcher; Spline Editing in Sketcher; Spline Creation in 3D.

3. Advanced Wireframe Geometry Unit Introduction:
   Projection Curves; Combined Curves; Intersection Geometry Creation; Parallel Curves; Reflect Lines; Connect Curve Creation; Helix Creation; Spiral Creation; Polyline Creation; Conic creation.

4. Basic Surfaces Introduction:
   Surfaces Overview; Basic Surfaces; Extruded Surfaces; Revolution Surfaces; Spherical Surfaces; Cylindrical Surfaces; Offsetting Surfaces; Swept Surfaces; Filled and Blended Surfaces; Multi-Sections Surfaces.

5. Surface and Wireframe Operations:
   Join Elements; Healing Elements; Trim Elements; Untrim Elements; Split Elements; Disassemble; Surface-Based Features (Thick Surface, Close Surface, Sew Surface).

6. Generative Structural Analysis in CATIA: An Introduction

7. Kinematics in CATIA: An Introduction

**prerequisite**

Completed Advanced Computer Aided Design or participant must be proficient in CATIA Part Design. Basic knowledge in CATIA assemblies is necessary.

**learning resources**

Handouts, Virtual classroom (Moodle), Power Point presentations, Computers with CATIA v5 software, Recommended literature and websites.

**number of hours**

lectures: 35
research: 0

**assessment of knowledge (maximum number of points - 100)**

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

references

A. Grbovic: Handouts, Faculty of Mechanical Engineering, Belgrade 2010.
Design of Mechatronic Systems

**ID:** PhD-3547  
**teaching professor:** Miladinović D. Ljubomir  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** seminar works

**goals**

Mastering the knowledge fund required for the competent synthesis of the structure of the mechatronic solution, defining the execution mechanism, the control module and the algorithm of the work. Developing the creative ability to set up a conceptual and operational mechatronic solution to meet the problem, which will optimally meet the defined technical requirements.

**learning outcomes**

Possessing the engineering capabilities to perform a high-quality synthesis of the mechanisms of the electronic and processor modules as key sub-blocks of the mechatronic solution. Precise solving of a direct engineering task, the synthesis of the original mechatronic solution, with the integration of specific modules and elements.

**theoretical teaching**

Designing in mechatronics; Initial vision of the concept of mechatronic solution, Mechanisms in mechatronics; Science on the theory of machines and mechanisms. Classification of mechanisms, Measurements in mechatronics 1; Analog and digital sensors, Measurements in mechatronics 2; Definition of photodiode light and phototransistors, Actuators in mechatronics; Linear and rotary actuators, Actuators with motion transformation, Digital and analogue electronic modules; Logic circuits and applications, Detection of state (0,1), Management concepts in mechatronics; Structure of the processor system, Programming the system; Programming tools available, Programming input ports, Programming output ports

**practical teaching**

Display of typical mechatronic solutions; Turbocharger with variable geometry, Decomposition of mechatronic solution; Analysis of elements, functions and signals of the sensor block, Elemental mechanisms; Examples of different configuration mechanisms for performing certain motion profiles, Sensors 1; Measurement of analogue sizes using PC-platform and Lab View software package, Sensors 2; Developing the idea for solving the user numerical-graphic display of results, Actuators; Motorized frequency drive control; Operational amplifier, Working with PC-platform, Working with PIC-platform;

**prerequisite**

None

**learning resources**

Models of mechanisms (articulated four-wire, piston mechanism) Set of sensors (thermocouples, inductive accelerometers, opto sensors). DC PIC development system Pneumatic components (cylinders, valves, PLCs)
number of hours

lectures: 35
research: 0

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 10
laboratory exercises: 20
calculation tasks: 5
seminar works: 10
project design: 15
final exam: 30
requirements to take the exam (number of points): 0

references
Design of Steam Turbines

ID: PhD-3390  
teaching professor: Petrović V. Milan  
level of studies: Ph.D. (doctoral) studies  
ECTS credits: 5  
final exam: written

goals

1. The achievement of research and expert competence in the field of steam turbines.
2. The achievement of high level of theoretical knowledge
3. The acquisition of research and expert knowledge to design and optimize steam turbines.
4. The achievement of the techniques of process modeling.
5. Methods of experimental work in thermal power engineering.

learning outcomes

1. Expert and research deep knowledge of the thermodynamic cycle in steam turbines.
2. The development of critical thinking about energy use, fuel efficiency and environmental preservation
3. The ability of design of steam turbines.
4. Ability to use computer technology for modeling and calculations

theoretical teaching


practical teaching

Project: Design of a Steam Turbine: Calculation of the main dimensions of a large steam turbine.

prerequisite

PhD student - Thermal power engineering

learning resources

Literature. Computing facility, software.

number of hours

lectures: 35  
research: 0

assessment of knowledge (maximum number of points - 100)

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

references

Stojanovic, Themal Turbomachinery, Gradjevinska knjiga, Belgrade, 1967.
A. Leizerovich: Steam Turbines for Modern Fossil-Fuel Power Plants
Lakshninarajana, B: Fluid Dynamics and Heat Transfer of Turbomachinery, Wiley, 1996,
Digital Forensics

**ID:** PhD-3181  
**teaching professor:** Mitrović B. Časlav  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written+oral

**goals**

The goal of this course is to familiarize PhD students with scientific methods for the identification, collection and analysis of data while preserving the original evidence and the chain of responsibility in the process of identifying potential digital evidence. Also, students will learn about the processes of collecting, preserving, analyzing and presenting digital evidence, as well as relevant forensic tools.

**learning outcomes**

Ability to contribute to scientific research. Student's ability to create and prepare scientific publications. Ability to organize and control scientific projects. Students will focus on scholarly application of digital forensics.

**theoretical teaching**

1. The concept and development of digital forensics. Classification of forensic tools.  
2. Analysis of forensic tools to implement and use areas.  
3. Analysis of forensic tools to code and computing platform.  
4. Forensic analysis tools used in different stages of the forensic investigation.  
5. Forensic tool that analyzes the hardware.  
6. Forensic tools that analyze code and programs.  
7. Forensic tools that analyze operating systems and networks.

**practical teaching**

Students will become familiar with a number of forensic tools that will be applied in several case studies. The first case study is related to the analysis of hardware and restore data from damaged hardware. The second case study is related to the monitoring of the operating systems.

**prerequisite**

No preconditions.

**learning resources**

All necessary programs can be found under the GNU license.

**number of hours**

lectures: 35  
research: 0

**assessment of knowledge (maximum number of points - 100)**
feedback during course study: 5
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 45
project design: 0
final exam: 50
requirements to take the exam (number of points): 50

references
Digital processing of non-stationary signals

**ID:** PhD-3430  
**teaching professor:** Jakovljević B. Živana  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** seminar works

**goals**

The objective of this course is that students master advanced techniques for digital processing of non-stationary signals acquired from dynamical systems primarily within manufacturing technology, as well as to acquire theoretical knowledge and practical skills necessary for effective extraction of representative features from signal.

**learning outcomes**

After successfully completing this course, the students should be capable to:
- Effectively de-noise one-dimensional and two-dimensional signals (acquired or in real time within control systems);
- Carry out Fourier, short-time Fourier and discrete wavelet transform;
- Generate system for features extraction from one-dimensional and two-dimensional signals;
- Recognize and implement signal processing technique of choice for concrete problem solving.

**theoretical teaching**

Classification of signals; Fourier transform; discrete Fourier transform; short time Fourier transform; finite impulse response (FIR) filters; synthesis of FIR filters; infinite impulse response (IIR) filters; continuous wavelet transform; discrete wavelet transform; families of wavelets and their characteristics; multi-resolution analysis; two-dimensional wavelet transform; Hilbert-Huang transform; two-dimensional signal processing; comparative analysis of techniques for digital processing of non-stationary signals

**practical teaching**

Implementation of studied techniques in solving of selected practical problems in digital processing of non-stationary signals, depending on PhD thesis subject

**prerequisite**

none

**learning resources**

General purpose programming languages for practical realization of digital signal processing  
Data acquisition system A2Logger  
Software for data acquisition  
Sensors (accelerometers, distance, dynamometers...)  
Development systems based on Atmega microcontrollers and dsPIC for practical realization in real-time  
Compilers
number of hours

lectures: 35
research: 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: 50
project design: 0
final exam: 50
requirements to take the exam (number of points): 35

references

Mallat, S., A wavelet tour of signal processing, Academic Press, San Diego, California, 1999
Dynamic problems of rail vehicles

**ID:** PhD-3569  
**teaching professor:** Milković D. Dragan  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** seminar works

**goals**

1. Deepening of knowledge in different areas of the dynamic behavior of railway vehicles.  
2. Become acquainted with advanced methods and tools for the study of the dynamic behavior of railway vehicles.  
3. Training for participation in research and development teams on the projects in the field of rail vehicle dynamics.

**learning outcomes**

After completion of the course a PhD student should be able to:

1. Apply advanced computational methods and computer tools in calculation of various parameters of the railway vehicle dynamic behavior.  
2. Analyze specific dynamic phenomena for the movement of rail vehicles.  
3. Participates in defining the research program of dynamic problems of rail vehicles.  
4. participate in the critical evaluation of research results.  
5. Participates in drawing conclusions about the quality of the research results.  
6. Participate in proposing future research directions of specific dynamic behavior problems of the railway vehicles.

**theoretical teaching**


**practical teaching**

Student makes seminar paper from a selected area upon agreement with relevant teacher and mentor of doctoral dissertation.

**prerequisite**

Previous knowledge of the railway vehicles design at the master course level. Previously completed course of the dynamics at the master level.
learning resources

Milutinović, D., Simić, G., Load and calculations of the railway vehicles wheels, Faculty of Mechanical Engineering, Belgrade 2006
Milković, D., Wayside systems for wheel-rail contact forces measurements, Faculty of Mechanical Engineering, Belgrade 2017

Publications from the SCI list

number of hours

lectures: 35
research: 0

assessment of knowledge (maximum number of points - 100)

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

references

Dynamics and Strength of Mining and Construction Machines

**ID:** PhD-3020  
**teaching professor:** Bošnjak M. Srdan  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** seminar works

**goals**

Basic course goals: 1) introducing students with specificities of dynamic processes of construction and mining machines; 2) introducing students with problems of strength of of construction and mining machines substructures; 3) mastering practical skills which are necessary for analysis of dynamic behavior and strength of construction and mining machines.

**learning outcomes**

This course offers its students competences in the following areas:
• Properly forming reduced dynamic models of the carrying structures and mechanisms of mining and civil machines, as typical representatives of complex dynamic systems with varying configuration, in accordance with the field of study;  
• Solving the problems of properly modeling excitation which is, in case of open-pit mining machine, of periodic nature;  
• Proficient analysis of the response of a dynamic system in conditions of continuous variation of constructional and excitation parameters;  
• Analysis and critical assessment of relevant literature and technical regulations in the related field of study.

**theoretical teaching**

Basic excavating machines dynamics – backhoe excavators and bulldozers. Dynamics of raw material fragmenting and sorting machines – crushers and screening machines. Dynamics and strength of machines for continuous excavation.

**practical teaching**


**prerequisite**

Required previously passed courses: Numerical methods, Vibrations of mechanical systems, Structural Analysis of Material Handling Machines

**learning resources**

1. Computers, Laboratory 516  
2. Software Matlab, Catia
number of hours

lectures: 35
research: 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: 70
project design: 0
final exam: 30
requirements to take the exam (number of points): 0

references

Srđan Bošnjak, Bucket Wheel Trenchers, University of Belgrade, Faculty of Mechanical Engineering, Belgrade, 2001.
Dynamics of a system of rigid bodies

ID: PhD-3122

teaching professor: Lazarević P. Mihailo

level of studies: Ph.D. (doctoral) studies

ECTS credits: 5

final exam: written

goals

To introduce students to fundamentals of system of rigid bodies, (SRB). It is possible to solve direct and inverse kinematics and dynamics task of (SRB) using the classical approach as well as modern theory of finite rotation and quaternions. Determination of the (simulation) models SRB-differential equations of motion SRB which are important in practical problems of dynamics of SRB.

learning outcomes

Attending the course students acquire the ability to analyze problems and synthesis solutions to the problem of rigid body dynamics system with the use of scientific methods and procedures as well as computer technology and equipment. Enabled him to connect knowledge of mechanics, mathematics, physics, the practical application of solving current problems of rigid body dynamics system.

theoretical teaching


practical teaching

Examples of determining the OTC. Determining the number of degrees of freedom for a given SRB. Application of Rodriguez matrix transformation-typical cases. An example of determining the configuration of a case of SRB-an industrial machine. Examples of application of the finite rotation and quaternions in spherical rigid body motion. Instances of the spherical rigid body motion-typical cases. Determination of the kinetic energy of the system of rigid bodies as well as the metric tensor of SRB. Application on a concrete example: a mechanical model of washing machines and robot Neuroarm as SRB. An instance of the formation of (contravariant)covariant forms of motion given SRB with 4-6 degrees of
freedom. Synthesis of optimal control SRB.

**prerequisite**

none

**learning resources**

2. Čović M. V. Lazarević, Mechanics of Robot, MF Belgrade, 2009. (Book)
5. Written abstracts from the lectures (Handouts)
6. Cyberbotics Webots - software package
7. Laboratory model of washing machine-4DOFs.
8. NeuroArm-laboratory robot-7 DOFs.
9. SimMechanics, GUI, (CSP)

**number of hours**

lectures: 35
research: 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: 50
project design: 0
final exam: 50
requirements to take the exam (number of points): 30

**references**

Dynamics of material handling and conveying machines

**ID:** PhD-3079  
**teaching professor:** Zrnić Đ. Nenad  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** seminar works

**goals**

The main objective of this course is to achieve competence of PhD students to master the principles of analysis dynamic behavior of support structures of material handling machines and conveyors and that is able to be incorporated into complex processes of their behavior under the action of various external loads.

**learning outcomes**

By completing this course student acquires ability to:
- model supporting structures of material handling and conveying machines
- define natural frequencies of material handling and conveying machines by applying Finite Elements Method
- analyse external loads of material handling and conveying machines
- evaluate the set up model
- get a dynamic response of dynamic system to external loads
- analyse alternative solutions in modeling process
- present obtained results of the research

**theoretical teaching**


**practical teaching**

Preparing a seminar work which should be a basis for publication of the research paper in the publication, such as international conference or scientific journal.

1. Introduction  
2. Set up of the problem  
3. Method of problem solving  
4. Analysis of the obtained results and discussion  
5. Conclusion  
6. References

**prerequisite**

The conditions are defined by the curriculum of the study program.
learning resources

5. Computers, Laboratory 516, ICT / CAH
6. KRASTA software package - program for statical and modal analysis of spatial frames, BSB Kühne GmbH, ICT / CSP.
7. Software SAP 2000 - program for statical and modal analysis of spatial frames.

number of hours

lectures: 35
research: 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: 70
project design: 0
final exam: 30
requirements to take the exam (number of points): 70

references

Ecodesign and sustainable logistics

**ID:** PhD-3402  
**teaching professor:** Zrnić Đ. Nenad  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** seminar works

**goals**

The main objective of this course is to achieve competence of PhD students to master the principles of ecodesign and life cycle assessment of a product, or a transport vehicle or equipment in a logistic system.

**learning outcomes**

By completing this course student acquires ability to:

- модел the life cycle of a product from cradle to grave
- define system boundaries
- classify and distinct relevant from irrelevant environmental impacts
- analyse obtained results in order to reduce environmental impact of a system
- evaluate benefits and drawbacks of emerging technologies from the environmental aspect

**theoretical teaching**


**practical teaching**

Preparing a seminar work which should be a basis for publication of the research paper in the publication, such as international conference or scientific journal.

1. Introduction  
2. Set up of the problem  
3. Method of problem solving  
4. Analysis of the obtained results and discussion  
5. Conclusion  
6. References

**prerequisite**

The conditions are defined by the curriculum of the study program.

**learning resources**

number of hours

lectures: 35
research: 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: 70
project design: 0
final exam: 30
requirements to take the exam (number of points): 70

references

Efficiency and reliability of weapon

**ID:** PhD-3156  
**teaching professor:** Milinović P. Momčilo  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** seminar works

**goals**

The basic goals of subject is to developed applied knowledge of weapon quality estimations and criteria for weapon evaluation, regarding their performances integrated in to the different conditions of Military employment. The system knowledge circled technical, ethnology and functional performances as relations integrated with theoretical and experimental statistics and probability modeling as the goal of subject skills. Education provides knowledge of weapon functionality, handling maintaining and warehousing as total quality inerrable conditions for their purpose measurement during tactical and design exploitation. Also coast effective analyses regarding weapon performances are included as measure for weapon comparing in preliminary study of design and-or their procurement. War game conditions with variable extreme performances exposing, have been estimated mathematically. Risk functions of weapon use is the subject of theoretical modeling. Overall goal is to provide mathematical and theoretical tool for final tactical and technical integrated design of weapon and weapon systems.

**learning outcomes**

Applicant (student), achieved knowledge of so called external functional design of weapon. Also, achieved knowledge about integration of different technical and technology performances of weapon in to the joint quality weapon systems performances valid for combat employment. This is estimated by random arguments probability functions of efficiency, reliability, hazard risk, coast effective, adaptability etc. This is the base for the organization and estimation of weapon units in organizational systems of systems at the further weapon commissioners.

**theoretical teaching**

Theoretical approach generally considering,  
- categorization of the weapons types, applicants for military organizational systems integrations  
- structure of reliability function applied on to the different weapon subsystems  
- efficiency and effectiveness criteria measurements and theoretical and experimental estimations  
- Theoretical criteria of war game equations and tactical and technical requirements modeling of weapon systems  
- technical integration of military units and their joint weapon efficiency  
- weapon platforms adaptability for reliable and efficiency design of weapon systems  
- equipment of weapon and their reliable and efficiency design  
- military handling, maintaining, supply and procurement functions, in logistics and battle field using

**practical teaching**
-Single weapon simulation function
- joint weapon simulation functions of probability and reliability
- Weapon and equipment integrated on the Platforms and accordance with efficiency and reliability
- Combat Military units war game modeling to efficiency and reliability of weapon and platforms

**prerequisite**

- Consultative, based on groups of lessons and practical consultations about seminar papers with selected types of weapon and combat platforms

**learning resources**

- Software and Computers
- Simulation laboratories
- External military proving ground laboratories in contract school deals of using

**number of hours**

lectures: 35
research: 0

**assessment of knowledge (maximum number of points - 100)**

feedback during course study: 5
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 15
seminar works: 20
project design: 30
final exam: 30
requirements to take the exam (number of points): 10

**references**

P. Przemensky, Mathematical modeling in defence analyses, AIAA Education, 2005
E. J. Eichblatt, Test and evaluation of tactical missile, AIAA, V 119, Progress in AA, 2001
End-of-life Vehicles

**ID:** PhD-3566  
**teaching professor:** Mitić R. Saša  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** seminar works

**goals**

The objective of the course is to familiarize with the ways in which vehicles at the end of their life impact on the environment. In particular, it is pointed to the disposal of vehicles at the end of the life cycle a relatively new field of research, primarily through statistical indicators in the vehicle market, as well as the formation of a global strategy in this area. Students are introduced to the infrastructure of vehicle recycling and processes used in the infrastructure, and the current approach to vehicle recycling at the end of its life is presented, i.e. current harmonized international regulations. The course presents a budget method for determining the degree of recyclability and degree of recoverability, as well as a formalized way of displaying the data obtained from the budget. It also points to the use of modern materials in design and production in the automotive industry from the point of view of increasing the degree of recyclability and degree of recoverability.

**learning outcomes**

Upon completion of this course, students should be trained:
- to recognize the ways of end-of life vehicles impact on the environment;
- to identify and explain processes defined by vehicle recycling infrastructure;
- to analyze and examine the impact of current international regulations in this field;
- to carry out the calculation of the parameters relevant to the impact of vehicles at the end of the life cycle on the environment and the performance of the data obtained through the defined formalized display;
- to analyze and evaluate the possibility of improving environmental protection by using modern materials in the automotive industry.

**theoretical teaching**

Introductory lectures relate to the presentation of statistics from the vehicle market, pointing to the importance of dealing with the challenges of an increasing number of vehicles at the end of their lifetime, as well as the ways in which these vehicles impact on the environment. The lectures analyze the current end-of-life vehicle recycling infrastructure, including processes, material flows and economic aspects of recycling. A significant part is also dedicated to defining the costs of disposal of recycling residues at landfills in the countries of the European Union and the world.

A special part relates to the presentation of current international and domestic regulations related to the vehicle recycling process, with particular reference to the process of vehicle approval and the conditions that vehicles must fulfill before being put into circulation. A budget method has also been presented in four steps, with the final goal of defining the values of recyclability and degree of vehicle recoverability through the design and production process.

The last segment of the lecture is dedicated to the use and application of modern materials in the automotive industry, with the aim of meeting the set criteria for the impact of vehicles at the end of life on the environment.
practical teaching

The content of practical lessons is in line with the studies that students should conduct.

prerequisite

- 

learning resources

- 

number of hours

lectures: 35
research: 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: 70
project design: 0
final exam: 30
requirements to take the exam (number of points): 40

references

Energy and environment

ID: PhD-3097
teaching professor: Jovović M. Aleksandar
level of studies: Ph.D. (doctoral) studies
ECTS credits: 5
final exam: seminar works

goals

The aim of this course is to cover important energy-related problems with considerable impact to the environment, by implementation of appropriate scientific methods. The subject is designed as an introductory course in the field of environmental engineering on PhD level. The key issues are effective and environmental friendly obtaining, exploration and conversion of energy resources, likewise distribution, transport and end-use of energy in different sectors.

learning outcomes

After completing the course, candidate will master with basic knowledge that concerns the analysis and evaluation of scientific work, fundamentals of experimental methods, modeling the energy facilities influence on environment and global climate change, as well as definition of the influenced parameters, modeling and optimization of energy facilities with regard to increasing the energy efficiency.

theoretical teaching


practical teaching

Preparation of energy audit questionnaire. Determination of Energy Cost Centers (ECC) within Energy Audit. Planning and preparation of measurement schemes of key parameters for material and energy balances within ECC as well as utility services in company. Implementation of energy audit in real industrial companies. Energy and material balances. Proposition of the list of energy efficiency measures. Calculation of energy savings for each proposed measure. Feasibility study and techno-economic analysis of proposed measures. Energy audit report. Presentation of energy audit results.

prerequisite

There is no previous requirements for attending this course.

learning resources

Laboratory and computational equipment
number of hours

lectures: 35
research: 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: 50
project design: 0
final exam: 50
requirements to take the exam (number of points): 0

references

Energy efficiency in industry

**ID:** PhD-3406  
**teaching professor:** Radić B. Dejan  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written

**goals**

Getting to know the candidates with problems and solving problems in the field of energy efficiency with appropriate scientific methods; subject is made as an advanced course in the area of energy efficiency at the doctoral studies.

**learning outcomes**

Upon completion of the course it is expected that the candidate has mastered the scientific knowledge pertaining to the analysis and evaluation of scientific papers, procedures and methods of energy auditing and testing, as well as the advanced processes of modeling, design and optimization of industrial plants from the viewpoint of energy efficiency.

**theoretical teaching**


**practical teaching**

Examples of Energy Efficient Systems: the use of waste heat, the steam supply and condense return systems, technical oxygen application in high temperature processes, combined heat and power generation, etc. Development of energy conservation projects in industrial plants. Methods of testing of thermal processes and equipment. Students work under the supervision of teacher one seminar paper that needs student to apply knowledge. If needed laboratory work and visits to industrial facilities.

**prerequisite**

-

**learning resources**

Laboratory and computational equipment.

**number of hours**

lectures: 35
research: 0

**assessment of knowledge (maximum number of points - 100)**

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

**references**

Scientific papers
Engineering Anthropometry

ID: PhD-3468

teaching professor: Spasojević-Brkić K. Vesna

level of studies: Ph.D. (doctoral) studies

ECTS credits: 5

final exam: written

goals

The objective of this course is to examine human factors issues relevant to work space design. Through this course students are trained for self-use of engineering anthropometry methods and for self-development of new models and improvement of existing models in different fields of engineering, so that they can design ergonomically adopted workplaces.

learning outcomes

By completing the program of this course students acquire following scientific and development abilities:
1. Full understanding of human dimensions important for engineering anthropometry methods.
2. Analytical skills needed to tackle the problems in work space design.
3. Conceptual skills for work space modeling.
4. Reasoning skills for work space modeling.
5. Skills to write scientific papers in the field.

theoretical teaching

1. Introduction to Engineering Anthropometry
2. Methods for Static and Dynamic Anthropometric Measurements
3. Statistical Methods for Engineering Anthropometry
4. Biometric Relationships
5. Anthropometry and systems safety
6. Applications Methodology
7. Workspace design Applications

practical teaching

Modelling of real engineering anthropometry problems / examples of passenger vehicles and crane cabins. Other examples. Case studies in the areas of theory in form of seminal work with possible paper publication. Practical part of this course will help students by providing a framework for solving real workspace design problems using the methods of engineering anthropometry.

prerequisite

Enrolled semester.

learning resources

5. Slides from Lectures
6. Scientific papers from Scopus, Science Direct and other databases

**number of hours**

lectures: 35  
research: 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: 50  
final exam: 50  
requirements to take the exam (number of points): 25

**references**

Scientific papers from Scopus, Science Direct and other databases
Engineering Management

ID: PhD-3348

teaching professor: Spasojević-Brkić K. Vesna

level of studies: Ph.D. (doctoral) studies

ECTS credits: 5

final exam: written

goals

The objective of this course is to examine issues relevant to growing technology businesses, developing products, improving processes, and leading technology based organizations that include both engineering and management aspects of engineering, and their integration. Through this course students are trained for self-use of engineering management tools and for self-development of new models and improvement of existing models in the field, so that they can navigate in increasingly complex and uncertain business environment and survey it.

learning outcomes

By completing the program of this course student acquires following scientific and research abilities:
1. Full understanding of various dimensions and functions of the broad field of engineering management.
2. Analytical skills needed to tackle the ever-changing problems and situations of modern competitive production systems.
3. Conceptual and reasoning skills with appropriate decision support methods and tools used in production management.
4. Modelling of contingency differences effects on the organizational design.
5. Understanding and modelling of the need for and requirements on sustainable and efficient production processes.

theoretical teaching

1. Management and Organization Principles
2. Organizational Structure and Design Principles applications
3. Organizational Design Models
4. Production Planning and Control. Methods and techniques.

practical teaching

Case studies in the field of theory. Tools, methods and techniques implementation. Modelling of real industrial examples. Report in form of seminal work with possible paper publication. Practical part of this course will help students in three ways: firstly, by providing a framework for managing individual and group performance; second, developing understanding of the leadership required manage the behaviour of people in organisations; and third, exploring the usefulness of the concepts and management practices discussed and used in case studies.
prerequisite

Enrolled semester.

learning resources

6. Slides from Lectures
7. Scientific papers from Scopus, Science Direct and other databases.

number of hours

lectures: 35
research: 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: 50
final exam: 50
requirements to take the exam (number of points): 25

references

Papers from scientific databases.
Environmental aspects of combustion

ID: PhD-3273
teaching professor: Stojiljković D. Dragoslava
level of studies: Ph.D. (doctoral) studies
ECTS credits: 5
final exam: oral

goals

Introduction to the issues and methods for reduction of environmental pollution from the combustion process.

learning outcomes

Acquisition of basic knowledge about the problems of environmental pollution from the combustion process and methods for pollution reduction.

theoretical teaching

Calculation of the quantity and composition of the flue gas at different stages and for different types of fuel. Classification of the flue gases by criteria of complete combustion and toxicity - impacts on the environment. The gaseous products of combustion - formation mechanisms, the impact on the combustion process, the impact on equipment / machinery, the options for reduction (considering the mechanisms of condensation, adsorption, gas-solid and gas-liquid absorption). Methods and procedures for reduction of sulfur and nitrogen compounds emissions. Solid particles - mechanisms of origin, impact and possibilities of flue gas cleaning.

practical teaching

Depending on defined topics of doctoral thesis the appropriate program of experimental work on the thesis is adopted.

prerequisite

none

learning resources

Laboratory facility / installation / machine (LPI):
1. Laboratory facility for investigation of the solid fuels combustion
Laboratory equipment for testing the fuels:
1. Various instruments for testing physical and chemical characteristics of solid and liquid fuels.
and other facilities and installations as needed

number of hours

lectures: 35
research: 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: 50
project design: 0
final exam: 40
requirements to take the exam (number of points): 30

references

Environmental engineering science

ID: PhD-3098

**teaching professor:** Jovović M. Aleksandar

**level of studies:** Ph.D. (doctoral) studies

**ECTS credits:** 5

**final exam:** seminar works

**goals**

The aim of this course is introducing candidates with problems and problem solving in the field of environmental protection by appropriate scientific methods; subject is designed as an introductory course in the field of environmental engineering at the level of doctoral studies; subject focuses on key points such as efficient and harmless systems for the environment, exploitation and conversion of energy sources, transportation and distribution, and use of final energy demand by end users in all sectors of production and consumption.

**learning outcomes**

At the end of the course it is expected that the candidate has mastered the basic knowledge related to the analysis and evaluation of scientific papers, the basis of laboratory work, and on the basis of the process of dispersion modeling of pollutants in the environment.

**theoretical teaching**

Introduction. Multidisciplinary of environmental protection. Process engineering and environmental protection. The effects of air, soil and water pollution, emissions, immissions. General legal basis for environmental protection and the basics of making norms. Possible sources of risk, risk and pollution levels, measuring the concentration of pollutants. Appropriate measures for living and working environmental protection. Technical standards, modalities of solving or planning. The design and operation of facilities, possibilities and use of low-polluting analogy from the standpoint of rational use of energy of materials and natural resources, equipment for air, fuel and water cleaning, classification and characteristics of the protection methods, application and properties of materials for construction of environmental protection equipment. Sources and types of solid, liquid and gaseous wastes, processes and waste treatment plants.

**practical teaching**

Laboratory work if needed; writing scientific papers etc.

**prerequisite**

There is no previous requirements for attending this course.

**learning resources**

Laboratory installation and measuring equipment if needed; numerous literature and access to numerous international databases.

**number of hours**

lectures: 35
research: 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: 50
project design: 0
final exam: 50
requirements to take the exam (number of points): 0

**references**

Epistemology of Science and Technique

**ID:** PhD-3549  
**teaching professor:** Zorić D. Nemanja  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** oral

**goals**

Introduce students to the history of science and technique.

**learning outcomes**

After examining the history of science and technology, students will be able to assess the future development and trends in science and technique.

**theoretical teaching**


**practical teaching**

- 

**prerequisite**

- 

**learning resources**

Dijem, P., Cilj i struktura fizičkih teorija, Novi Sad, 2003.

**number of hours**

lectures: 35  
research: 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: 50
project design: 0
final exam: 50
requirements to take the exam (number of points): 30

references

Dijem, P., Cilj i struktura fizičkih teorija, Novi Sad, 2003.
Especial Chapters of Theory of Machines and Mechanisms

**ID:** PhD-3564  
**teaching professor:** Jeli V. Zorana  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written

**goals**

To familiarize students with the latest developments in the theory of machines and mechanisms related to the analysis and synthesis of mechanisms, mechanisms of variable structure, spatial mechanisms, cam mechanisms, gear and cloc mechanisms.

**learning outcomes**

Students acquire the necessary knowledge and skills required to design and construct mechanisms and machines. Also, students are trained in the use of appropriate programs for analysis of kinetic mechanisms of different size structures.

**theoretical teaching**


**practical teaching**

Accomplishing the project work whose theme is closely related to doctoral student works.

**prerequisite**

No conditions

**learning resources**

Individual determination of the required literature from Theory mechanisms and machines. Literature in foreign languages, Internet content.

**number of hours**

lectures: 35  
research: 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: 70  
project design: 0  
final exam: 30  
requirements to take the exam (number of points): 0
references
Experimental aerodynamics

ID: PhD-3451
teaching professor: Mitrović B. Časlav
level of studies: Ph.D. (doctoral) studies
ECTS credits: 5
final exam: written+oral

goals

The aim with course is that students should learn how to plan, conduct, and process data from wind tunnel tests. Student should develop increased understanding of basic physical phenomena and their influence on the performance of aircraft. Also, this course provide students with an opportunity to observe first hand aerodynamic phenomena that have been introduced in previous courses; Introduce students to practical elements of experimental aerodynamics and develop appreciation for how the aerodynamic data obtained by measuring required and applied;

learning outcomes

Ability to contribute to scientific research. Student's ability to create and prepare scientific publications. Ability to organize and control scientific projects. Provide the students with an opportunity to apply modern instrumentation and measurement techniques to the acquisition of aerodynamic data and understand the inherent limitations of each technique; Become proficient in estimating experimental uncertainty; Teach students to critically analyze the results of their experiments and present them in a concise and logical form, both in written and oral; Comparisons between experimental and computational results are used to gain experience to decide what type of investigations are most suitable for an experimental approach. Gaining experience in the use of microprocessors for experimental applications.

theoretical teaching

1. Introduction
2. Aerodynamic testing facilities
3. Data acquisition
4. Aerodynamic measurement techniques
5. Measurement of force and torque
6. Pressure measurements
7. Temperature measurements
8. Velocity measurements
a) Hot-wire Anemometry
b) Laser Doppler Velocimetry (LDV)
c) Particle Image Velocimetry (PIV)
9. Boundary layer measurements
10. Flow visualization
11. Wind tunnel corrections
12. Other measurement techniques
practical teaching

Laboratory exercises accompany the theoretical classes. Are based on a number of projects. Each project was initiated at a lecture on the topic of each project. Students in small groups make initial assessments and planning to test in a wind tunnel. Followed by actual testing in the wind tunnel, which is done in small groups. Finally, in the computer lab to collect, analyze and process the test data.

prerequisite

without conditions

learning resources

Laboratory for Aerotechnics
Wind tunnel
Hot-wire Anemometry
Laser Doppler Velocimetry (LDV)
Particle Image Velocimetry (PIV)
Information Technology Laboratory

number of hours

lectures: 35
research: 0

assessment of knowledge (maximum number of points - 100)

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

references

Experimental Fluid Mechanics, P. Bradshaw, Pergamon Press, 1970
Low-Speed Wind Tunnel Testing, Rae, W. and Pope, A.
Experimental data acquisition and processing

ID: PhD-3548

teaching professor: Jakovljević B. Živana

level of studies: Ph.D. (doctoral) studies

ECTS credits: 5

final exam: seminar works


goals

1) To receive basic knowledge about sensors, signals conditioning and experimental data acquisition;
2) To receive basic knowledge about methods for design of experiments (DOE);
3) To receive practical knowledge about experimental data processing;
4) To receive training in testing procedures for machine tools and machining systems;
5) To know how to make technical projects and testing report.

learning outcomes

Upon successful completion of this course students should be able to:
1. Apply knowledge about sensors in the setting of experiments with electrical measuring of mechanical quantities;
2. Form a plan for preparing the experiment;
3. Complete the installation for measurement and data acquisition;
4. Complete the calibration of transducers and the prepare of components for signal conditioning;
5. Configure the application in the software for data acquisition, for measurements with visualization and storing of time series of measured quantities;
6. Use files with time series of measured quantities for subsequent digital processing for identification of unknown parameters of object or process;
7. Prepare Technical Elaborate and reports about testing.

theoretical teaching

New teaching contents:
1) Sensors for testing of machine tools and machining systems; Dynamometers; Accelerometers;
2) Design of experiment (DOE);
3) Signal conditioning and experimental data acquisition;
4) Experimental data processing;
5) Methods for identification of continuous-time models from sampled data.

Elaboration of new teaching contents and instructions for doing the tasks:
1) Sensors preparing and calibrations;
2) Preparing for the designed experiments;
3) Experimental setup for data acquisition;
4) Methods and software for experimental data processing;
5) Examples for identification of continuous-time models from sampled data.

practical teaching

Practical teaching involves laboratory work in Laboratory for machine tools and machining systems, and seminar work writing. Planned experiments are carried out in the Laboratory
with finishing the reports. These reports are a part of the seminar work.

**prerequisite**

none

**learning resources**

Laboratory for machine tools and machining systems, which includes both hardware and software:
1) Different kinds of sensors (accelerometers, dynamometers etc.);
2) The systems for experimental data conditioning and acquisition;
3) Software for experimental data processing;
4) The systems for laboratory testing of machine tools accuracy;
5) The system for circular interpolation test;
6) Test bed for identifying parameters of mechanistic cutting forces models;
7) Test bed for cutting process optimization, feed scheduling, and integrated simulation of machine tool and process;
8) Software for virtual machining system simulations;
9) Test bed for parallel kinematics machine tools;
10) Test bed for configuring and programming of modular open architecture machine tools (MOMA);
11) Test bed for the STEP-NC protocol based programming of CNC machines;
12) Hardware needed for basic modal analysis (modal hammer, accelerometers etc.);
13) Software for basic modal analysis;
14) Functional simulator of the rapid prototyping machine tool;
15) Software for basic optimization of machine tools structures.

**number of hours**

lectures: 35
research: 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: 70
project design: 0
final exam: 30
requirements to take the exam (number of points): 50

**references**


Explosive applications

ID: PhD-3542
teaching professor: Elek M. Predrag
level of studies: Ph.D. (doctoral) studies
ECTS credits: 5
final exam: written

goals

Acquiring knowledge from the field of explosive application and testing.

learning outcomes

Student gets knowledge in the field of application and testing of explosives for various military purposes.

theoretical teaching

Introduction to explosives.
Fundamentals of physics of explosive processes.
Theories and methods of initiation of explosives.
Explosive propulsion.
Testing of explosives.

practical teaching

Fundamentals of physics of explosive processes - calculation examples.
Theories and methods of initiation of explosives - selected examples.
Explosive propulsion - Gurney method.
Testing of explosives - analysis of different testing methods.

prerequisite

No.

learning resources


number of hours

lectures: 35
research: 0

assessment of knowledge (maximum number of points - 100)

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

references

Failure Diagnostic

**ID:** PhD-3032

**teaching professor:** Vencl A. Aleksandar

**level of studies:** Ph.D. (doctoral) studies

**ECTS credits:** 5

**final exam:** oral

**goals**

The student attending this course should:
- Comprehend the significance of failures from the technical and economic aspects;
- 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**

On the basis of mastered knowledge the student is qualified to:
- Describes and distinguishes types of failures (casual, permanent, partial, immediate and gradual failure) and diagnosis techniques in the construction and maintenance of mechanical systems;
- Describes and distinguishes different types of maintenance, with its advantages and disadvantages;
- Applies proactive maintenance, using benchmarking and roadmaps to excellence;
- Assesses the importance of failure and analyze maintenance costs;
- Make a fault tree, i.e. perform FMEA and Pareto analysis of machine elements and systems;
- Define the necessary parameters and procedures that allow failures monitoring and contribute to the contemporary maintenance procedure of machinery and equipment, and special tribological systems and mechanisms.

**theoretical teaching**


**practical teaching**

Preparing of the seminar paper.

**prerequisite**

No special requirements.

**learning resources**

**number of hours**

- lectures: 35
- research: 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: 70
- project design: 0
- final exam: 30

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

**references**

Fatigue and life estimation of aeronautical stuctures

**ID:** PhD-3415  
**teaching professor:** Grbović M. Aleksandar  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** project design

**goals**

The goal of this course is to introduce students to the field of fatigue of aircraft structures. Including basic theoretical knowledge of fatigue and fracture mechanics, students are trained for proper use of modern software tools. After attending the cours, finishing all exercises and giving the final presentation, students should be able to identify the cause of fatigue cracks, type of load that brought to the development of fatigue cracks and to analyze aircraft structural life to the occurrence of fatigue cracks and to determinate residual aircraft structural life. Also, after passing the course students should be independent in estimation where fatigue crack will occur in the structure, based on a known load spectrum, by using modern software tools.

**learning outcomes**

By successfully adopting the program of the course, a student acquires theoretical and practical knowledge to recognize type of fatigue, to determine the critical point for the fatigue crack appearance, to recognize the nature of the dynamic loads, task boundary condition for the simulation of crack growth, independent assess which numerical method gives the best problem approximation, and to determine the fatigue life of the structure before and after the fatigue crack.

**theoretical teaching**

1. Introduction to fatigue life assessment of aircraft structures.  
2. Basic concepts in the study of fatigue characteristics.  
3. Introducing the concept of damage tolerance, safe and reliable structure.  
4. Introduction to elastic fracture mechanics in the assessment of fatigue crack growth and residual strength of aircraft structures.  
5. Presentation in describing the static fracture and residual strength of the structure.  
6. Analytical and numerical determination of crack growth.

**practical teaching**

Practical training accompanies materials presented during theoretical lectures. In the beginning, students will be familiarized with work on computer and modern software tools, followed by presentation of the examples that illustrate the theoretical lessons. Examples cover complete problems, i.e. setting the boundary conditions, correction in solving complex problems, graphical representation of solution and its analysis. Students will solve their homework independently and present it to colleagues.

**prerequisite**

Fundamental background in FEM is recommended.

**learning resources**
Handouts, Virtual classroom (Moodle), Powerpoint presentations, Computers with ANSYS and Abaqus software, Recommended literature and websites.

**number of hours**

lectures: 35  
research: 0

**assessment of knowledge (maximum number of points - 100)**

feedback during course study: 40  
test/colloquium: 0  
laboratory exercises: 0  
calculation tasks: 10  
seminar works: 0  
project design: 20  
final exam: 30

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

**references**

Jovičić G., Živković M., Vulović S., Proračunska mehanika loma i zamora, Mašinski fakultet Univerziteta u Kragujevcu, Kragujevac, 2011.(in Serbian)
Fatigue of Thin Walled Structures

ID: PhD-3380
teaching professor: Grbović M. Aleksandar
level of studies: Ph.D. (doctoral) studies
ECTS credits: 5
final exam: written

goals

The goal of this course is to provide students with a theoretical and practical knowledge of the modern techniques for fatigue data acquisition, data analysis, test planning and practice. More specifically, it covers the most comprehensive methods to capture the thin walled structure load, to identify and characterize the scatter of fatigue resistance and loading and to perform the fatigue damage assessment of a structure. Basic concepts of fracture mechanics are also covered.

learning outcomes

Knowledge of the mechanism of crack initiation in the material and how crack propagation in thin walled structures can be predicted using different methods are the most important outcomes of this course. The students will also gain knowledge about so-called “design against fatigue” and will be able to predict (with good accuracy) the fatigue performance of thin walled structures, fatigue limits, fatigue lives until crack initiation and the remaining life covered by crack growth until final failure.

theoretical teaching

1. Basic Concepts of Fatigue and Fracture
5. FE and Analytical Calculations of Elastic Anisotropy Stresses to Predict Crack Initiation Sites; ANSYS software.

practical teaching

1. Cycle Counting Techniques Through Examples - LEVEL CROSSING CYCLE COUNTING, PEAK-VALLEY CYCLE COUNTING, RANGE COUNTING, RAINFLOW METHOD.
2. Stress-Based Fatigue Analysis and Design Through Examples
3. Fracture Mechanics and Fatigue Crack Propagation: Examples (ANSYS, Abaqus, FRANC2D&3D)
**prerequisite**

Fundamental background in FEM is recommended.

**learning resources**

Handouts, Virtual classroom (Moodle), Powerpoint presentations, Computers with ANSYS and Abaqus software, Recommended literature and websites.

**number of hours**

lectures: 35  
research: 0

**assessment of knowledge (maximum number of points - 100)**

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

**references**

A. Grbovic, Handouts, Faculty of Mechanical Engineering, Belgrade, 2012.  
Finite element method

**ID:** PhD-3570  
**teaching professor:** Buljak V. Vladimir  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written

**goals**

The objective of this course is to provide to the students thorough theoretical and practical basis for the Finite Element Method (FEM). It will be shown how to apply this method in order to find an approximate solution to the boundary value problems in elasticity. The solution will be fully developed for displacement-based finite elements. Recovery of strains and stresses will be further demonstrated for single field approximations (just the displacement field) but also two field and three field independent approximations. These strategies will be demonstrated for finding the approximate solution of coupled problems, with reference to thermo-mechanical coupling problems. The problem of shear locking for quasi-incompressible solids will be treated in details with the employment of selective integration techniques and incompatible modes elements. The implementation of constitutive models into existing FEM codes will be exemplified on commercial software ABAQUS and open source software CODE_ASTER.

**learning outcomes**

Upon completing the course the students will be able to apply linear theory of finite element method in order to:
- write codes for building the stiffness matrix for structural and continuum finite elements;
- perform finite element analysis within commercial software ABAQUS;
- perform analysis within open source software package CODE_ASTER;
- write their own subroutines for the implementation of constitutive models within the existing software.

**theoretical teaching**


**practical teaching**

Writing codes in FORTRAN, C++ or Python, for the assembling of stiffness matrix for structural finite elements (trusses and beams) and continuum elements in 2D and 3D. Performing quasi-static and dynamic analysis in commercial software ABAQUS and open source software CODE_ASTER. Examples of enlarging the capabilities of existing software by the implementation of user sub-routines for the implementation of material constitutive modeling.

**prerequisite**

-
learning resources

2. Introduction to computational plasticity. Fionn Dunne and Nik Petrinic.

number of hours

lectures: 35
research: 0

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 0
laboratory exercises: 5
calculation tasks: 5
seminar works: 40
project design: 0
final exam: 50
requirements to take the exam (number of points): 30

references

Non-linear finite element analysis of solids and structures – Volume 1. M.A. Crisfield
Introduction to computational plasticity. Fionn Dunne and Nik Petrinic
Computational methods in plasticity: Theory and applications. EA de Souza Neto, D. Peric and DRJ Owen.
Finite Elements Methods in Applications

**ID:** PhD-3342  
**teaching professor:** Grbović M. Aleksandar  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written

**goals**

The goal of this course is to provide students with a practical knowledge of the finite element method and the skills required to analyze engineering problems with ANSYS, a commercially available FEA program. In addition to the fundamental topics, course presents advanced topics concerning modeling and analysis. These topics are introduced through extensive examples in a step-by-step fashion from various engineering disciplines.

**learning outcomes**

This course gives students a sense of how the finite element method can be used, not only to calculate the response of complex structures that have already been defined, but also to develop a good understanding of structural behaviour that can be used in design. By completing the course, students will acquire a foundation of knowledge of completed works of structural engineering and will be able to solve advanced problems using software for finite element analysis (ANSYS).

**theoretical teaching**

1. INTRODUCTION  
   Concepts, Nodes, Elements, Direct Approach.
2. FUNDAMENTALS OF ANSYS  
3. FUNDAMENTALS OF DISCRETIZATION  
   Local and Global Numbering, Approximation Functions, Coordinate Systems, Shape Functions
4. ANSYS PREPROCESSOR  
5. ANSYS SOLUTION AND POSTPROCESSING  
   Solution, Analysis Options/Solution Controls, Boundary Conditions, Initial Conditions, Body Loads, Solution in Single and Multiple Load Steps, Failure to Obtain Solution, Postprocessing, General Postprocessor, Time History Postprocessor, Read Results, Plot Results, Element Tables, List Results.
6. LINEAR STRUCTURAL ANALYSIS  
   Static Analysis, Linear Buckling Analysis, Thermomechanical Analysis, Fracture Mechanics Analysis, Dynamic Analysis.
7. NONLINEAR STRUCTURAL ANALYSIS  
   Geometric Nonlinearity, Material Nonlinearity, Combined Plasticity and Creep, Contact.
8. ADVANCED TOPICS IN ANSYS
Coupled Degrees of Freedom, Writing Data to External ASCII Files, Executing an External File, Modifying the ANSYS GUI

**practical teaching**

Practical examples - Trusses, Beams, Three-dimensional Problems, Two-dimensional Idealizations, Plates and Shells, Modal Analysis, Harmonic Analysis, Large Deformation Analysis of a Plate, Post-buckling Analysis of a Plate with a Hole, Plastic Deformation of an Aluminum Sphere, Plastic Deformation of an Aluminum Cylinder, Fracture Analysis of a Plate With Hole.

**prerequisite**

Fundamental background in finite element method is required.

**learning resources**

Handouts, Virtual classroom (Moodle), Powerpoint presentations, Computers with ANSYS software, Recommended literature and websites

**number of hours**

lectures: 35
research: 0

**assessment of knowledge (maximum number of points - 100)**

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

**references**

A. Grbovic, Handouts, Faculty of Mechanical Engineering, Belgrade, 2009.
Fire control and command- information systems

**ID:** PhD-3157  
**teaching professor:** Milinović P. Momčilo  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written

**goals**

To introduce applicants with modern control systems of fire power activities, and control functions of weapon during proceedings of combat exploitations based on theoretical approach of mechanics and mathematics in the variable and virtual initial and eugenvales conditions of launching and projectiles flight of different integrated weapon and combat platforms types. To observed technology integration of weaponized unit effect, combat platform, and weapon during combat deployment, with modern defence information technologies of Control and Command in the 3D space. To determined the properties of digitalized and full integrated battle field during time in aim to tracking and control of combat organizational weaponized systems on the C4I levels

**learning outcomes**

Applicant achieved knowledge for individual design of weapon systems functions with appropriate equipment integrated in to the weapon subsystem. Knowledge achieved are about types and character of equipment and sensors for shooting functions control and space navigation of weaponized systems. Proceedings are accorded with requirements of Mechanics and Mathematics, respecting accuracy and precision of Weapon and equipment.

**theoretical teaching**

Theoretical lessons circled,  
- probabilities of shooting accuracy and precisions of weapon  
- Mechanics and following proceedings of shooting with different projectiles  
- Digitalization of targets tracking and shooting performances measurements  
- The types of mil.sensors  
- Navigation of air, land, and water platforms based on inertial and GPS satellite systems  
- Time proceedings and ordering of command systems and units.

**practical teaching**

- Simulation software on the computer

**prerequisite**

Consultative of seminar papers

**learning resources**

Computers and software systems
number of hours

lectures: 35
research: 0

assessment of knowledge (maximum number of points - 100)

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

references

M. Milinovic, Modeling of FC and tracking Systems of areal targets, (serb), EDIT. OF, MEF, BGD, 2002
C. Gacovic, Tracking of low altitudes areal targets Peack impoulse LOS radars, VIZ.BGD, 1999
M. Kolawole, Radar systems peck detection and tracking, Newnes, Oxford, 2002
Fractional calculus with applications in engineering

**ID:** PhD-3128
**teaching professor:** Lazarević P. Mihailo
**level of studies:** Ph.D. (doctoral) studies
**ECTS credits:** 5
**final exam:** oral

**goals**

Introduce students to basic concepts of fractional calculus. It is possible to solve problem of modeling as well as control task of the fractional order system (FOS) using modern theory based on fractional calculus. Determination (simulation) models of FOS - i.e. fractional differential equations of motion of the FOS, as well as fractional order controls which are important in practical problems of the FOS. Practical simulations FOS using MATLAB software package.

**learning outcomes**

By attending this course student acquires the ability to analyze problems and synthesis solutions to the problem of modeling and control of given fractional order systems using scientific methods of fractional calculus. This enabled him applying solutions to practical problems of fractional order systems as well as monitoring and implementation of innovation of new results of fractional calculus.

**theoretical teaching**


**practical teaching**

Applications MATLAB for given fractional order system-examples in engineering.

**prerequisite**

none

**learning resources**

1. M. Lazarević, Lj. Bučanović, Contribution to modelling and dynamical analysis of fractional order system with fundamentals of fractional calculus
5. AV Pskhu, AP Soldatov, Partial differential equations of fractional order, Nauka, Moscow, 2005
6. Written abstracts from the lectures (Handouts)
7. MATLAB, MATHEMATICA - mathematics software packages

**number of hours**

lectures: 35
research: 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: 50
project design: 0
final exam: 50
requirements to take the exam (number of points): 30

**references**

K. S. Miller, B. Ross, An Introduction to the Fractional Calculus and Fractional Differential Equations, John Willey & Sons, Inc. 1993
**Fuels and selected topics in combustion**

**ID:** PhD-3272  
**teaching professor:** Stojilković D. Dragoslava  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** oral

**goals**

Introduction to modern approaches of characterization, production, processing and application of fuel.

**learning outcomes**

Acquiring knowledge about modern methods of characterization, production, processing and application of fuels (solid, liquid and gas).

**theoretical teaching**


**practical teaching**

Depending on defined topics of doctoral thesis the appropriate program of experimental work on the thesis is adopted.

**prerequisite**

none

**learning resources**

Laboratory facility / installation / machine (LPI):
1. Laboratory facility for investigation of the solid fuels combustion  
Laboratory equipment for testing the fuels:
1. Various instruments for testing physical and chemical characteristics of solid and liquid fuels.  
and other facilities and installations as needed

**number of hours**

lectures: 35  
research: 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: 50
project design: 0
final exam: 40
requirements to take the exam (number of points): 30

references

Gas-Liquid Two-Phase Flow and Heat Transfer

**ID:** PhD-3524  
**teaching professor:** Stevanović D. Vladimir  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** seminar works

**goals**

Simulation and analysis of various gas-liquid two-phase flow patterns in power, thermal and chemical plants and equipment. Prediction of pressure change in two-phase flow, evaporation and condensation rate and heat transfer on two-phase flow channel wall.

**learning outcomes**

Development of analytical models of two phase flows based on the balance equations and closure laws. Two-phase flow models solving and simulation and analyses of two-phase flows in energy, thermal or chemical plants and equipment during steady-state or transient conditions.

**theoretical teaching**


**practical teaching**

Development of a two-phase model for chosen operational conditions of energy, thermal or chemical plant/equipment. Models solving, validation and verification. Simulation and analyses of plant/equipment operational conditions by using the developed model.

**prerequisite**

Passed exams in Thermodynamics, Fluid Mechanics and Higher Mathematics at Bachelor or Master university studies.

**learning resources**

Lecture notes, computer equipment, in-house and commercial computer codes for two-phase flow simulations.

**number of hours**

lectures: 35  
research: 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: 60
project design: 0
final exam: 30
requirements to take the exam (number of points): 0

references

Stevanovic, V., Thermal-Hydraulics of Steam Generators – Modelling and Numerical Simulation, University of Belgrade, Faculty of Mechanical Engineering, 2006.
Gas Turbines – Selected topics

**ID:** PhD-3370
**teaching professor:** Petrović V. Milan
**level of studies:** Ph.D. (doctoral) studies
**ECTS credits:** 5
**final exam:** written

**goals**

1. The achievement of research and expert competence in the field of gas turbines.
2. The achievement of high level of theoretical knowledge
3. The acquisition of research and expert knowledge to optimize gas turbines.
4. The achievement of the techniques of process modeling.
5. Mastering the methods of experimental work in thermal power engineering.

**learning outcomes**

1. Expert and research deep knowledge of gas turbines.
2. The development of critical thinking about energy use, fuel efficiency and environmental preservation
3. The ability of calculate gas turbines.
4. Ability to use computer technology for modeling and calculations

**theoretical teaching**


**practical teaching**


**prerequisite**

PhD student - Thermal power engineering.

**learning resources**

Literature. Computing facility.

**number of hours**

lectures: 35
research: 0

**assessment of knowledge (maximum number of points - 100)**
feedback during course study: 10
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 20
seminar works: 20
project design: 0
final exam: 50
requirements to take the exam (number of points): 30

references

Stojanovic, Themal Turbomachinery, Gradjevinska knjiga, Belgrade, 1967.
Krieger, 2004
Guided missiles navigational systems

**ID:** PhD-3543  
**teaching professor:** Todić N. Ivana  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** seminar works

**goals**

This course is based on the acquisition of knowledge of navigation systems, primarily inertial navigation and a global positioning system, with the goal that the information derived from the navigation systems can be used trajectory guidance or the path correction.

**learning outcomes**

After this course, the student is trained for independent work in the field of navigation systems and acquires the necessary knowledge to participate in new development projects in this field.

**theoretical teaching**

Basics of inertial navigation. Historical development of inertial navigation and strapdown INS. Coordinate systems. Kinematic Euler equation and algorithms of solving (Euler's angles, quaternions, Hamilton's parameters, Rodrigues’s theorem). Gyroscopes and accelerometers. Calibration of inertial units, testing and error correction. The basics of the global positioning system. Integrated navigation systems.

**practical teaching**


**prerequisite**

none

**learning resources**


**number of hours**

215
lectures: 35
research: 0

**assessment of knowledge (maximum number of points - 100)**

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

**references**

**Helicopter Rotor Aerodynamics**

**ID:** PhD-3180  
**teaching professor:** Mitrović B. Časlav  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** project design

**goals**

The aim is to provide the optimal design of the main rotor modeling of unsteady lift through a series of entities which are geared toward the preliminary and main rotor helicopter project. Thus, through the this course processed model of the concept of optimal aerodynamic rotor design that matches the behavior of the rotor in real terms, and that is enough quality in terms of engineering applications. Consideration of the actual rotor in this course can be applied with sufficient accuracy in the analysis and constructive performance rotor helicopter in realistic conditions.

**learning outcomes**

The ability to deal with scientific research. Student’s ability to create and prepare scientific publications. Ability to organize and monitor research projects. Students will be focused on the use of modern aerodynamic analysis, which is also open to the possibility of using available computer techniques circumvent the often unnecessary and very expensive experiment.

**theoretical teaching**

1. General Features of Flow Field  
2. Decomposition of Flow Field  
3. Flow Around the Rotor Blades  
4. Modeling Wake  
5. Vortex Methods of Flow Simulations  
6. Helicopter Rotor Aerodynamic Characteristics in Level Flight  
8. Aerodynamic Characteristics Helicopter Rotor on Hover  
9. Helicopter Rotor Aerodynamic Characteristics when Climbing Angle

**practical teaching**

Students from each topic given homework to the teacher who submitted the assessment. At the end of lectures students presented their the project. The quality of the paper and the final presentation of the project are determine for the final exam.

**prerequisite**

No preconditions

**learning resources**

Computer lab, licensed software, projector, laptop

**number of hours**
lectures: 35
research: 0

**assessment of knowledge (maximum number of points - 100)**

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

**references**

Časlav Mitrovic, Modeling of Unsteady Helicopter Rotor Lift, Faculty of Mechanical Engineering, 2002
Jacob Shapiro, Principles of Helicopter Engineering, McGRAW HILL BOOK CO.INC
Higher course of heat and mass transfer operations and apparatus

**ID:** PhD-3037  
**teaching professor:** Genić B. Srbislav  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written+oral

**goals**

Introduction to the trends of research in the field of heat and mass transfer apparatus  
Mathematical modeling of the intensity of heat and mass transfer in process equipment

**learning outcomes**

The application of the basic models of phase fluidodynamic state for estimation of the heat and mass transfer efficiency

**theoretical teaching**

Two phase heat transfer: evaporation, condensation, freezing. Heat and mass transfer operations accompanied with chemical reactions. Optimization capabilities of heat and mass transfer operations and apparatuses.

**practical teaching**

**prerequisite**

**learning resources**

**number of hours**

lectures: 35  
research: 0

**assessment of knowledge (maximum number of points - 100)**

feedback during course study: 10  
test/colloquium: 50  
laboratory exercises: 0  
calculation tasks: 10  
seminar works: 0  
project design: 0  
final exam: 30  
requirements to take the exam (number of points): 70
references

Higher course of process energy and high-temperature devices and processes

**ID:** PhD-3496  
**teaching professor:** Stamenić S. Mirjana  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written

**goals**

Expansion of basic knowledge in the field of process energy and high-temperature devices and processes. Analysis and modeling of high-temperature processes and optimization of high-temperature devices present in high energy intensive industrial branches.

**learning outcomes**

Mastering the knowledge and tools for research and practical work in the field of energy efficiency improvement of devices in process energy. Mastering the mathematical modeling and design procedures for calculation of heat transfer intensity at high-temperature devices and processes. Training for mastering the design procedures for design of high-temperature equipment for research work.

**theoretical teaching**

Basic concepts of energy efficiency and how to use energy in production processes in the industry (the definition of energy efficiency of energy systems in industrial plants, energy companies balance, energy indicators, energy policy).  
Review of high temperature devices and processes in specific industrial sectors (Industrial furnaces, boilers, combustion systems).  
Resources and measures for increasing the energy efficiency in industry (Overview of potentials and measures in energy and production systems).  
Presentation of methods for modeling and optimization of high temperature processes (combustion, heat transfer in the furnaces, radiation, heating of materials, modeling of processes in industrial furnaces, energy balance).

**practical teaching**

Examples of research in the field of heat transfer, with particular emphasis on the heat exchange by radiation. Lobo-Evans method for calculation of the combustion chamber within the process furnaces.

**prerequisite**

Defined by curriculum of study program.

**learning resources**

Lab and measuring equipment, literature resources listed within the Literature chapter.

**number of hours**

lectures: 35
research: 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: 30
project design: 0
final exam: 60
requirements to take the exam (number of points): 30

**references**

Higher course of process phenomena

**ID:** PhD-3495  
**teaching professor:** Stamenić S. Mirjana  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written+oral

**goals**

Expansion of basic knowledge in the field of transport phenomena and heat substances in the process industry. Application of steady and unsteady state heat and mass transfer in two phase multiple component systems in process equipment.

**learning outcomes**

Mastering of mathematical modeling and design procedures necessary to determine the intensity of heat and mass transfer and pressure drop in chemical apparatuses. Training for the research and design in the field of process equipment.

**theoretical teaching**

Molecular transport phenomena.  
Steady and unsteady state heat and mass transfer in fluids.  
Differential equations of convective transport of momentum, heat and substance.  
Laminar and turbulent flow.  
Simplified models of convective transport.  
Analysis of heat and mass transfer resistances.  
Coefficients of heat and mass transfer.  
Similarity theory.  
Anallogies between mass, heat and momentum transfer.  
Mass transfer across a phase boundary.  
Inter-phase turbulence.  
Simultaneous mass and heat transfer.  
Wet-bulb temperatures.  
Boiling, condensation and thermal radiation.  
Typical cases in process equipment (heat exchangers, columns, furnaces).  
Unsteady heat and mass transfer in solid phase.

**practical teaching**

Examples of the research in the field of heat and mass transfer and pressure drop

**prerequisite**

-

**learning resources**

Resources are books listed within chapter - Literature

**number of hours**

223
lectures: 35
research: 0

**assessment of knowledge (maximum number of points - 100)**

feedback during course study: 10
test/colloquium: 50
laboratory exercises: 0
calculation tasks: 10
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 70

**references**

Higher mathematic

**ID:** PhD-3398  
**teaching professor:** Radojević LJ. Slobodan  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written+oral

**goals**

The course of higher mathematics consists of two parts. The first part is devoted to the study of algebraic structures, from group theory to the vector space. Certain applications in mechanical engineering are presented with eigenvalues and eigenvectors. The second part of the course devoted to partial differential equations. Taught partial equations of first and second order. Applications in mechanical engineering is presented by the equation of heat conduction.

**learning outcomes**

PhD student will be familiar with the small part and partial linear algebra and partial equations, but will have a basis for further work and applications in mechanical engineering.

**theoretical teaching**

1. Vectors in $\mathbb{R}^n$ and $\mathbb{C}^n$. Linear Equations.  
4. Eigenvalues and eigenvectors.  
5. General concepts of partial differential equations.  
8. The equation of heat conduction. Laplace equation.

**practical teaching**

Auditory tasks and exercises to fully follow the lecture.

**prerequisite**

Standard mathematics courses.

**learning resources**

Chalk and blackboard.

**number of hours**

lectures: 35  
research: 0

**assessment of knowledge (maximum number of points - 100)**
feedback during course study: 5
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 45
project design: 0
final exam: 50
requirements to take the exam (number of points): 50

references

Human - machine interface 1

ID: PhD-3572
teaching professor: Spasojević-Brkić K. Vesna
level of studies: Ph.D. (doctoral) studies
ECTS credits: 5
final exam: written

goals

The objective of this course is to develop students scientific and development skills in the field of human-centered design, so that they understand and critically examine human capabilities and limitations (emphasizing cognitive factors such as perception, information processing, memory, and motor control) that must be considered in order to design human-machine systems that are safe, comfortable and efficient. Team projects will be used to experience an iterative design process that includes analysis of user needs and product goals, conceptual design, physical design, prototyping, usability testing, and refining of the design.

learning outcomes

By completing the program of this course students acquire following professional skills:
1. To conduct fieldwork with people to get design ideas.
2. To get feedback from other stakeholders like teammates, clients, and users.
3. To effectively organize and present information with interfaces.
4. To use principles of perception and cognition that inform effective interaction design and how to perform and analyze controlled experiments online.
5. To write scientific papers in the field.

theoretical teaching

• Introduction and Overview
• Need, Concept and Features of HMI
• HMI Types
• HMI Specifications and Selection Criteria
• HMI Configuration and Application
• Design for Human Computer Interaction in Web-based Applications

practical teaching

• Project Development
• Creating Project
• Testing HMI s and
• Results discussion.
Team projects will be used to experience an iterative design process that includes analysis of user needs and product goals, conceptual design, physical design, prototyping, usability testing, and refining of the design.

prerequisite

Enrolled semester

learning resources
6. Slides from Lectures
7. Scientific papers from Scopus, Science Direct and other databases

**Number of hours**

lectures: 35
research: 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: 50
final exam: 50
requirements to take the exam (number of points): 0

**References**

Hydrodynamic lubrication theory

ID: PhD-3306  
teaching professor: Crnojević Đ. Cvetko  
level of studies: Ph.D. (doctoral) studies  
ECTS credits: 5  
final exam: written

goals

Introducing the hydrodynamic lubrication theory, its application and mathematical calculation methods of flow in the bearings.

learning outcomes

Mastering the physical-mathematical calculation methods of flow in the bearings of variable geometry which can be: Newtonian (incompressible and compressible) or a non-Newtonian fluid, or diluted gas.

theoretical teaching

The course is entirely done by the book:  

practical teaching

Seminar paper.

prerequisite

No special requirements.

learning resources

number of hours

lectures: 35  
research: 0

assessment of knowledge (maximum number of points - 100)

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

references
IC engines dynamic problems

ID: PhD-3424
teaching professor: Miljić L. Nenad
level of studies: Ph.D. (doctoral) studies
ECTS credits: 5
final exam: seminar works

goals

The aims of the course are to provide theoretical and practical study about dynamic behavior of the engine mechanism. The analysis of engine dynamics problems such as: balancing of inertia forces and their moments, crankshaft angular speed variations and crankshaft torsion vibrations require analytical approach, mathematical modelling of the phenomena and experimental testing in order to identify unknown parameters and verify analytical results.

learning outcomes

The merger of theoretical knowledge of mechanics, basics of strength of constructions and machine elements and its applications on specific problems of engine dynamics. Training students for mathematical modeling of engine mechanisms dynamic as well as for experimental testing of phenomena originating from engine dynamics: crankshaft angular speed variations and crankshaft torsion vibrations.

theoretical teaching

2. Engine crank mechanism as torsional vibrations system. Equivalent torsional system; reduction of system elements masses and lengths; degrees of freedom; modes and frequencies of free torsional vibrations. Determination of the free vibrations frequencies based on Holzer method. Forced torsional vibrations; harmonic analysis of forcing torques; system resistances and damping; main harmonics of forcing torque, resonance and critical engines rotational speeds. Technical possibilities of torsional vibration damping; torsional vibration dampers. Evaluation of amplitudes and stresses of resonant torsional vibrations.

practical teaching

1. Evaluation of variable mass moment of inertia of engine crank mechanism; practical examples.
2. Gas, inertia and friction forces torques evaluation. Crankshaft rotational speed evaluation.
4. Connections between angular speed variations and engine working process and the possibilities of diagnostics based on angular speed measurements.
5. Practical examples of engine crank mechanism equivalent torsional system evaluation (reduction of system masses and lengths). Evaluating of free torsional vibrations frequencies.
7. Experimental measurements of engine crankshaft torsional vibrations.
prerequisite

No prerequisites required.

learning resources

4. Test bench for engine testing; angular encoders for front and rear crankshaft end. Computer acquisition system for high speed measurements; system of pressure traducers and amplifiers for in-cylinder pressure recordings.

number of hours

lectures: 35
research: 0

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 0
laboratory exercises: 50
calculation tasks: 0
seminar works: 20
project design: 0
final exam: 30
requirements to take the exam (number of points): 60

references

Impact Mechanics

**ID:** PhD-3562  
**teaching professor:** Zorić D. Nemanja  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written

**goals**

The aim is that the issue of mechanical impact (collision) procedures as wide, and point out the methods of describing processes occurring in the solid body in a short time period of collision, including aspects from the standpoint of classical mechanics, the contact stresses and strains, wave propagation phenomena and occurrence of plastic deformations.

**learning outcomes**

Knowledge of four major aspects in the evolution of impact theory:
- Classical mechanics
- Contact mechanics
- Plastic deformation
- Stress wave propagation.

An ability to identify, formulate, and solve simple problems in impact mechanics.

An ability to systematically review, analyze, assimilate and interpret professional literature and innovations in spectrum of different theories for collision.

An ability to produce high quality research, and disseminate effectively the research output in reputable international journals, conferences, research proposals and other scientific venues.

**theoretical teaching**


**practical teaching**

**prerequisite**

Defined by the curriculum study of Phd studies program.

**learning resources**


**number of hours**

lectures: 35
research: 0

**assessment of knowledge (maximum number of points - 100)**

feedback during course study: 0
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 60
seminar works: 0
project design: 0
final exam: 40
requirements to take the exam (number of points): 50

**references**

Пановко Я.Г., Введение в теорию механического удара, Наука, Москва, 1977.
Industrial Design

**ID:** PhD-3350  
**teaching professor:** Spasojević-Brkić K. Vesna  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written

**goals**

Through this course students are encouraged to learn to develop and survey new products and experience typologies within the context of current and emerging human needs. Objectives of this course are:

- to increase awareness of the need for and role of ergonomics in occupational health
- to obtain scientific knowledge in the application of ergonomic principles to design of industrial workplaces and the prevention of occupational injuries
- to understand, apply and critically examine scope of occupational ergonomics.

**learning outcomes**

After successfully completing this course students should be able to:
1. Assess and discuss the overall value of applying human factors concepts to improve the safety & efficiency of complex systems.
2. Demonstrate mastery of appropriate Human Factors Engineering methods, theories and concepts.
3. Critically analyse the role of human factors in complex systems. In particular, students should be aware of the critical contribution of human factors to the successful design and operation of safety critical systems.
4. Demonstrate independent and creative application of human factors concepts to real world situations.
5. Critically evaluate equipment design features and successfully communicate possible countermeasures for problem areas identified.

**theoretical teaching**

1. Introduction to Human Factors Engineering  
2. Equipment design: human machine interaction, new technologies, usability, standardisation, automation & behavioural responses.  
3. User-Centered Analysis and Conceptual Design  
4. Practical Usability Testing  
5. Risk Factors  
6. Anthropometry and Workplace Design  
7. Ergonomics standards and regulations  
8. Ergonomics Assessment Methods  
9. Human Errors, Accidents and Investigation  
10. Safety management systems and safety culture  
11. Human Factors, Management & Organisation

**practical teaching**

Examples of User-Centered Design. Case studies with aim to recognize and construct proper recommendations to correct human factors deficiencies in human-machine systems. Design, conduct, and document a human factors experiment or study for a research project.
prerequisite

Enrolled semester.

learning resources

6. Slides from Lectures
7. Scientific papers from Scopus, Science Direct and other databases.

number of hours

lectures: 35
research: 0

assessments

feedback during course study: 0
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 50
final exam: 50
requirements to take the exam (number of points): 25

references

Industrial robots modelling and simulations

ID: PhD-3531  
teaching professor: Slavković R. Nikola  
level of studies: Ph.D. (doctoral) studies  
ECTS credits: 5  
final exam: seminar works

goals

The student should acquire basic knowledge in modelling and simulation of industrial robots kinematics, dynamics, calibration, programming and application.

learning outcomes

After completed this course the students should be able to:

(1) Perceive the importance of modelling and simulation of industrial robot kinematics, dynamics, calibration, programming and application.
(2) Apply actual methods, techniques and software for industrial robot modelling, simulation and analysis.
(3) Estimate and use the results of modelling and simulation in development, design and/or robot application.

theoretical teaching


practical teaching

Laboratory exercises are related to the theme of the PhD thesis and include: kinematics and dynamics robot modelling, calibration, program simulation and verification, modelling and simulations of robotized cells.

Practical research in the field of modelling and simulation of industrial robots related to the theme of the PhD thesis.

Writing seminar work in the field of modelling and simulation of industrial robots related to the theme of the PhD thesis.

Publication of research paper.

prerequisite

Undergraduate or Master course in the field of Industrial robotics.

learning resources

Laboratory for Industrial robotics and artificial intelligence (Robotics & AI), with 5 industrial robots, software for simulation and programming Workspace5.
Center for parallel kinematic machines (CeMPK) with two parallel kinematic machine tools and DELTA robot.

**number of hours**

- lectures: 35
- research: 0

**assessment of knowledge (maximum number of points - 100)**

- feedback during course study: 0
- test/colloquium: 0
- laboratory exercises: 40
- calculation tasks: 0
- seminar works: 30
- project design: 0
- final exam: 30

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

**references**

Information Management

ID: PhD-3346

teaching professor: Misita Ž. Mirjana

level of studies: Ph.D. (doctoral) studies

ECTS credits: 5

final exam: oral

goals

Acquisition of skills necessary for independent design or participation in the team for design of information flow.

learning outcomes

Upon successful completion of this course, students should be able to:
- use common methodologies for information flow design,
- design a information flows in companies,
- carry out estimation of efficiency information flows in company,
- management of information flows.

theoretical teaching

1. Introduction into the information management, information flows diagrams
2. Structured Systems Analysis (SSA), SSADM methodology
4. Computer systems analysis
5. Tools for system analysis. Decomposition of computer systems
6. Methodology of design of information systems. Planning and phases. Defining the goal, analysis, global design of information systems.

practical teaching

A case-study from the field of design of information flows diagrams.

prerequisite

Enrolled 2nd semester of doctoral studies.

learning resources

On-line electronic database for academic purpose, Software packages for design of information diagram flows

number of hours

lectures: 35
research: 0

assessment of knowledge (maximum number of points - 100)

feedback during course study: 30
test/colloquium: 0
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

Integrated Technical Systems - Actuators

ID: PhD-3466
teaching professor: Miloš V. Marko
level of studies: Ph.D. (doctoral) studies
ECTS credits: 5
final exam: seminar works

goals

Train students to be familiar with methods and techniques of engineering design of the actuator as a representatives of a complex integrated technical systems.

learning outcomes

Students will gain knowledge that will qualify them to realize complex processes of modeling, simulation and integration of different kinds of actuators.

theoretical teaching

Design methodology of integrated structures, computer models and simulations of electro-mechanical (EMA), hydraulic (EHA) and pneumatic (EPA) actuators.

practical teaching

Modeling and simulation of complex actuator systems. Upon completion of the calculation and simulation, practical work with actuator: measurement of certain parameters and synthesis of control;
Practical work may be related to student's doctoral thesis.
Optional: publication of scientific paper.

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), Laboratory for Hybrid Technical Systems.

number of hours

lectures: 35
research: 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: 70
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

R. Dorf, R. Bishop: Modern Control systems – Pearson, 2011.
Integration of smart actuators and sensors

**ID:** PhD-3205  
**teaching professor:** Petrović B. Nebojša  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** seminar works

**goals**

Smart materials are materials that have properties that can be significantly changed in a controlled fashion by external stimuli. Such materials can be used for detection and activation, thus making the smart actuators and sensors. Due to their compact size and unique properties they have applications in aerospace industry, robotics, biotechnology.... The goal of this course is to expose the students to the principles of smart materials with an emphasis on their use and integration in aerospace applications. Students will be introduced to smart material fundamentals, their thermo-mechanical and elektro-magnetic properties and couplings between these fields. During the course topics concerned with design, modeling, control and fabrication of smart structures are presented and various examples are demonstrated. Through exercises, students will explore potentials of smart actuators and sensors and challenges associated with their uses.

**learning outcomes**

During the course, students will acquire the knowledge necessary for understanding the fundamental behavior of smart materials. They will be introduced to the mathematical models that describe the behavior of smart materials and to the principles of smart sensors and actuators construction. Also, by experimenting with different types of smart structures control algorithms during the practical part of the course, students will gain experience and operational knowledge that can be utilized in real life applications throughout their career.

**theoretical teaching**

Introduction to Smart Materials,  
Piezoelectric Materials and Magnetostrictive Materials constitutive relationship  
Smart Actuators and Micromechatronics - Basics, Applications, Current and future trends  
Smart Sensors - Basics, Applications, Current and future trends  
Integration of Smart Sensors and Actuators to Smart Structures  
Optimal Placement of Sensors and Actuators  
Design of Controller for Smart Structure

**practical teaching**

Practical exercises follows the course content. During the exercises the student develops computer models of smart structures, performs numerical analysis and applies different algorithms for control and optimization of smart structure.

**prerequisite**

There is no necessary requirement for attendance of Integration of smart actuators and sensors.

**learning resources**

Faculty of Mechanical engineering — course catalog — Ph.D. (doctoral) studies  
243
Simlab - computer laboratory

**number of hours**

lectures: 35
research: 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: 70
project design: 0
final exam: 30
requirements to take the exam (number of points): 70

**references**

Selected research articles and conference papers.
Additional materials (written handouts, problem setting, guidelines for problem solving...)
Intelligent Automation

ID: PhD-3207

Teaching professor: Petrović B. Petar

Level of studies: Ph.D. (doctoral) studies

ECTS credits: 5

Final exam: written

Goals

Specialized knowledge in the field of design and realization of industrial automation with embedded elements of artificial / machine intelligence and autonomous behavior, focused to various research topics in the domain of mass customization manufacturing paradigm.

Learning outcomes

Practical knowledge and skills in modeling and simulation of dynamical systems. Skills in application of fuzzy logical systems and neural networks in modeling and practical realization of complex systems that have autonomous behavior and capability to work in non-well structured working environment.

Theoretical teaching


Practical teaching

Practical teaching is mostly governed by the needs of the student in his doctoral dissertation and takes place in the laboratory.

Prerequisite

Continuous and discrete systems of manufacturing systems control, Numerical control of machine tools and robots, Cybernetics, Mechatronics systems

Learning resources

Laboratory for CyberManufacturing Systems at the Department of Production Engineering has extensive experimental resources, which include industrial robots, various sensory and actuation systems, as well as development systems for microcontrollers and related digital systems.

Number of hours

Lectures: 35
Research: 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: 70
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

Kasabov, N. and Kozma, R., (Eds) Neuro-Fuzzy Techniques for Intelligent Information
Kosko, B., Neural Networks and Fuzzy Systems: A Dynamical Systems Approach to Machine
Bolton, W., Mechatronics: Electronic Control Systems in Mechanical and Electrical
Zi-Xing Cai, Intelligent Control: Principles, Techniques And Applications, Series in
Intelligent industrial robots

ID: PhD-3530  
teaching professor: Slavković R. Nikola  
level of studies: Ph.D. (doctoral) studies  
ECTS credits: 5  
final exam: seminar works

goals

The student should acquire basic knowledge related to new methods and technics in industrial robots modelling, programming, sensors and intelligence.

learning outcomes

After completed this course the students should be able to:

(1) Perceive the importance of industrial robot intelligence.
(2) Apply actual methods, techniques, software and sensors to enhance industrial robot intelligence for given technological tasks.
(3) Integrate different sensors (sensors fusion) to enhance industrial robot intelligence for given technological tasks.

theoretical teaching


practical teaching

Laboratory exercises are related to the theme of the PhD thesis and include: sensors fusion, vision systems and intelligent path planning.

Practical research in the field of industrial robot intelligence related to the theme of the PhD thesis.

Writing seminar work in the field of industrial robot intelligence related to the theme of the PhD thesis.

Publication of research paper.

prerequisite

Undergraduate or Master course in the field of Industrial robotics.

learning resources

Laboratory for Industrial robotics and artificial intelligence (Robotics & AI) with 5 industrial robots, software for simulation and programming Workspace5.

Center for parallel kinematic machines (CeMPK) with two parallel kinematic machine tools...
and DELTA robot.

**number of hours**

lectures: 35  
research: 0  

**assessment of knowledge (maximum number of points - 100)**

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

**references**

Introduction to Operations Research

**ID:** PhD-3520  
**teaching professor:** Bugarić S. Uglješa  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written+oral

**goals**

Course goal is overwhelm with academic basic scientific methods and quantitative techniques for obtaining alternative (optimal) solutions of real world problems on which basis user can perform analysis and synthesis of given solutions, make decision and predict consequences.

**learning outcomes**

Solution of concrete problems with application of scientific methods, procedures and techniques using analysis, synthesis and prediction of solutions and consequences as well as overwhelm with methods, procedures and research processes and application of knowledge (gained skills) in practice.

**theoretical teaching**


**practical teaching**

Audit lessons (examples of linear programming, transportation problem, nonlinear programming, dynamical programming. Examples of project management – structure analysis, time analysis cost analysis. Examples of application of queuing theory models – finite and infinite source of customers, single and multi server without and with partial and complete help between servers. Examples of service system optimisation. Application of simulation and Monte Carlo method in analysis and modelling of service systems. Examples from area of decision making and forecasting.). Laboratory work (the use of adequate software).

**prerequisite**

Students should have a background in probability, statistics, mathematics, computer science.

**learning resources**

2. Software: QSopt Version 1.0 (Linear programming problems).

5. Personal computers.

**number of hours**

lectures: 35
research: 0

**assessment of knowledge (maximum number of points - 100)**

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

**references**

Hillier, F. S., Lieberman, G. J.: Introduction to operations research (seventh edition),
Inverse analysis in material characterization

ID: PhD-3512
teaching professor: Buljak V. Vladimir
level of studies: Ph.D. (doctoral) studies
ECTS credits: 5
final exam: written

goals

To solve a direct problem means to find analytical or numerical solution for ordinary or partial differential equations that are describing given problem. By having a minimum set of information about the problem, referred to as the condition of uniqueness, one can use powerful tools available nowadays to find a solution for a problem at hand. Inverse problems are defined as those in which some of these data are missing and they should be identified from the known solution of connected direct problem. Sub-group of inverse problems represents parameter identification problems, which are the main focus of this course. The course provides a synergic combination of experimental techniques with numerical simulations and mathematical programming to build a practical procedure based on inverse analysis that should be used for the assessment of unknown material parameters. In the main focus are parameter characterization problems in structural mechanics, although most of the material is applicable with slight modifications also to other engineering fields. Within a structural context discussed in the course, simulations of the experiments are done by finite element modeling (FEM), traditionally by commercial software. The training is oriented to the numerical implementation, and participants will gain practical knowledge in coupling numerical simulations done by commercial codes with optimization routines written by them to have a fully automated procedure for the assessment of material parameters.

learning outcomes

After fulfilling this course the students will be able to:
- Understand various techniques and iterative algorithms used in the theory of numerical optimization.
- Write codes in MATLAB aimed to numerically solve the optimization problems by using first order optimization algorithms.
- Write codes for interfacing MATLAB with ABAQUS (commercial FEM software) required for automatic modification of input files necessary for FEM analysis.
- Generate fully working inverse analysis procedures by writing all necessary codes and putting them together in order to solve problems of material parameter identification.

theoretical teaching

Theoretical lectures of the course are giving main concepts of selected, most popular, optimization algorithms that are discussed up to the details of their successful implementation. Detailed theoretical background on optimization theory is omitted in the course, but potentially interested students can be guided through available literature on particular topics. Further on, the concept of inverse analysis is presented and typical types of ill-posedness are covered with appropriate measures for their overcoming. Sensitivity analysis are discussed first in a traditional manner, namely the numerical calculations of first derivatives with respect to sought parameters. Second the propagation of measurements uncertainty is evaluated again through sensitivity analysis by simulating different level and type of measuring noise.
practical teaching

Each particular technique discussed on lectures is practiced through numerical implementation exercises. Further on, simulations of various engineering experiments are performed in a commercial FEM code ABAQUS and the interfaces to be used for practical inverse analysis procedures are written in MATLAB. In final parts of the course a practical procedure based on developed techniques is designed aimed to assess elasto-plastic properties of material starting from indentation tests.

prerequisite

Students should also be familiar with basic programming techniques preferably in MATLAB

learning resources


number of hours

lectures: 35
research: 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: 50
project design: 0
final exam: 50
requirements to take the exam (number of points): 30

references
Isogeometric analysis

**ID:** PhD-3507  
**teaching professor:** Peković M. Ognjen  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** project design

**goals**

Isogeometric Analysis (IGA) is a numerical method for approximate solutions to boundary-value problems in science and engineering. Its peculiarity is that the numerical approximation uses the same basic functions that are used to construct a CAD geometric model (Non-uniform rational B-spline (NURBS) are standard in contemporary CAD industry). In this way, it is possible to perform analysis directly on CAD model without meshing. The goal of the course is to acquaint students with the concept of isogeometric analysis, specifically in comparison to the classical Finite Element Method. Student will gain operational knowledge through programming of small IGA code and learn about problems that arise in implementation of IGA.

**learning outcomes**

After completing the course, students gain practical and theoretical knowledge that will serve as a basis for further research and practical work in the field. By programming small IGA code students obtain working experience in IGA implementation and foundation for further upgrade and practical implementation of the new achievements in IGA in own code. Students will learn about possibilities of increase of NURBS basis functions degree and advantages that this property offers in the field of mechanics of elastic bodies.

**theoretical teaching**

- Introduction and overview of IGA development  
- Geometrical foundations – NURBS geometry  
- Equations of elastomechanics  
- Approximation methods  
- Interpolation functions in conventional FEM  
- Domain discretization in IGA  
- Boundary conditions in IGA  
- Quadrature in IGA  
- Multipatch geometries  
- Modern alternatives to NURBS basis functions in IGA

**practical teaching**

- Becoming familiar with the methodology of computer implementation of IGA through programming own IGA code  
- Modeling of NURBS geometries  
- Solving of selected problems in elastomechanics  
- Comparison of the obtained results with the results of commercial software packages for finite element analysis.
No obligatory prerequisites. Good knowledge of Matlab is desirable.

**learning resources**

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

**number of hours**

lectures: 35
research: 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: 70
final exam: 30
requirements to take the exam (number of points): 80

**references**

Rogers D., 2001, An Introduction to NURBS With Historical Perspective, Morgan Kaufmann Publishers, San Francisco
**Lubrication Theories**

**ID:** PhD-3033  
**teaching professor:** Vencl A. Aleksandar  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** oral

**goals**

The student attending this course should:
- Examine the complexities of lubrication process and its importance in the construction of the main tribological elements;
- Get familiar with the standards for the calculation of main tribological elements;
- Learn the basic principles of main lubrication types and how they should be applied in the design process.

**learning outcomes**

On the basis of mastered knowledge the student is qualified to:
- Analyze fundamental aspects of boundary lubrication;
- Analyze fundamental aspects of mixed lubrication;
- Analyze fundamental aspects of hydrodynamic lubrication;
- Analyze fundamental aspects elastohydrodynamic lubrication;
- Analyze fundamental aspects of hydrostatic lubrication;
- Define the basic assumptions for the calculation of main tribological systems, according to standards, and based on the lubrication theories.

**theoretical teaching**

The introductory section includes a definition of the lubrication process, forms and types of lubrication and lubricant rheology. Fundamental aspects of lubrication, defined by Reynolds equation, and the study of its solutions: theory of infinite length bearing, short bearing and bearing with finite length. Calculation methods that use hydrostatic, gasostatic, hydrodynamic, gasodinamic and elastohydrodinamic lubrication theory. In particular, boundary and mixed lubrication are studied, including the study of lubricants in these conditions.

**practical teaching**

Preparing of the seminar paper.

**prerequisite**

No special requirements.

**learning resources**


**number of hours**

lectures: 35
research: 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: 70
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

**references**

Machine Dynamics

**ID:** PhD-3563  
**teaching professor:** Šiniković B. Goran  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** project design

**goals**

Mastering the knowledge fund needed to: approximate a real machine equivalent to the mechanism of the mechanism with mass and inertial discretization of components, further calculation of dynamic forces and moments, balancing the mechanism, solving the suspension, setting a concept for testing the dynamics of the machine. Developing the creative ability to set up a dynamic problem to set up a conceptual and operational solution that will optimally meet the defined ISO technical norms on the dynamics of machines.

**learning outcomes**

Acquiring engineering skills to perform a qualitative analysis of the machine or mechanisms, as well as the associated sub-folders, and to make a 3D model based on it. The engineering skill to precisely solve a direct task, to discover the focus of a dynamic initiative within the machine to then propose an existing solution and create a new one that will have a minimized initiative. In addition, it is mastered by knowledge for balancing dynamic forces and wiring, and conceiving control and overseeing excessive vibration in operation.

**theoretical teaching**


**practical teaching**

Practical teaching; laboratory exercises; Display typical machine and mechanism configurations. Virtual Works (Solid Works - Motion). Display of laboratory and field measurement equipment. Practical work with equipment. Measuring vibration, balancing and modal testing. Checking acceptability according to ISO standards.

**prerequisite**

No condition

**learning resources**

PHYSICAL MODELS MECHANISMS Solid Works Motion Vibration Sensors Deformetri Data Logger Micro Mon Rotobalance, a portable Vibrodygnostic Platform for Dynamic Testing

**number of hours**

257
lectures: 35
research: 0

**assessment of knowledge (maximum number of points - 100)**

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

**references**
Magnetohydrodynamic flows

ID: PhD-3133

**teaching professor:** Lečić R. Milan

**level of studies:** Ph.D. (doctoral) studies

**ECTS credits:** 5

**final exam:** oral

**goals**

Student will be introduced to theory and problems of flow of conductive fluid in presence of magnetic field.

**learning outcomes**

Gaining knowledge from some theoretical and practical problems of magnetohydrodynamics. This knowledge can be used for scientific work in this area of research.

**theoretical teaching**


**practical teaching**

Research on a specific problem of Magnetohydrodynamics.

**prerequisite**

Passed exam in Selected Chapters in Fluid Mechanics.

**learning resources**

**number of hours**

lectures: 35
research: 0

**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): 0
references

Maintenance and Quality Management System

**ID:** PhD-3261  
**teaching professor:** Spasojević-Brkić K. Vesna  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written

**goals**

The aim of the course is the acquisition of competencies for the application of research methods in the areas of maintenance and quality management, on the basis of already acquired knowledge and skills.

**learning outcomes**

By mastering this course the student gets the following scientific and research capabilities:
1. Diagnose the current state of the maintenance system,
2. Diagnosing the current state of the quality management system,
3. Design of new models of the maintenance system,
4. Design of new models of quality management system,
5. Writing scientific papers in the field of the course.

**theoretical teaching**

1. Importance, organizational factors and maintenance management system  
2. Importance, organizational factors and the structure of quality management systems  
3. Organizational Design Factors and maintenance system  
4. The organizational structure of the maintenance function  
5. Quality Management System and organizational changes  
6. Quality management and business performances relationship  

**practical teaching**

Case studies in the areas of theory in form of seminal work with possible paper publication.

**prerequisite**

Enrolled semester

**learning resources**

6. Scientific resources on Scopus, Science Direct etc.

**number of hours**

261
lectures: 35
research: 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: 50
project design: 0
final exam: 50
requirements to take the exam (number of points): 20

**references**

Milivoj Klarin, Gradimir Ivanović, Petar Stanojević - Terotechnology (in Serbian) - ICIM Kruševac 2001
Scientific resources on Scopus, Science Direct etc.
Man - machine interface

ID: PhD-3075

Teaching professor: Žunjić G. Aleksandar

Level of studies: Ph.D. (doctoral) studies

ECTS credits: 5

Final exam: seminar works

Goals

The goal of this course is to inform students with advanced techniques and recommendations for designing of selected segments from the domain of man - machine interface.

Learning outcomes

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

• Apply the ergonomic recommendations for designing of specific controls
• Design labels on mechanical systems and products in accordance with ergonomic principles
• Design the selected interface elements in the human - computer system in accordance with the ergonomic recommendations
• Implement control of errors in a human - computer system
• Design on-line help and instructions for use based on the application of ergonomic heuristics
• Design the control rooms from the ergonomic aspect
• Apply in practice the methods for assessing the reliability of a man - machine system
• Identify the causes of accidents in the man - machine system
• Apply in practice the methods for ergonomic assessment of working postures

Theoretical teaching


Practical teaching

Writing a seminar paper regarding the chosen topic.

Prerequisite

Defined by Regulation on doctoral studies.

Learning resources

Tachistoscope, sound level meter, konimeter, psychrometer, lux meter, anthropometric measuring equipment, available in the lab. 417.

Number of hours

263
lectures: 35
research: 0

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 65
project design: 0
final exam: 30
requirements to take the exam (number of points): 50

references

Mass, momentum and energy transport phenomena

**ID:** PhD-3268  
**teaching professor:** Stevanović D. Nevena  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written

**goals**

The aim of this subject is getting knowledge about fundamental aspects of the transport phenomena (mass, momentum and energy transport) and developing skills for the application to various practical problems.

**learning outcomes**

Students are trained to develop mathematical models of thermalhydraulic processes, where mass, momentum and energy transport phenomena is coupled and to solve them by analytical and numerical methods.

**theoretical teaching**

Theoretical lessons incorporates the heat, momentum and mass transfer field which includes studies of convection, radiation, conduction, evaporation, condensation, boiling and two-phase flow in the laminar and turbulent flow, as well as transport phenomena in support of micro-scale and nano-scale sciences.

**practical teaching**

Practical lessons contains applicationc of the heat, momentum and mass transfer field which includes studies of convection, radiation, conduction, evaporation, condensation, boiling and two-phase flow in the laminar and turbulent flow, as well as transport phenomena occurring in micro and nano-science.

**prerequisite**

Passed exam in Fluid mechanic and Thermodynamics.

**learning resources**

Course handouts.

**number of hours**

lectures: 35  
research: 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: 50
project design: 0
final exam: 50
requirements to take the exam (number of points): 50

references

Mathematical methods in fluid mechanics

ID: PhD-3158

teaching professor: Milićev S. Snežana

level of studies: Ph.D. (doctoral) studies

ECTS credits: 5

final exam: written

goals

Fluid mechanics is complex scientific discipline. The goal of the subject is to learn mathematical methods which is necessary in study of specific areas of fluid mechanics.

learning outcomes

The results from this topic will be gained knowledge from specific areas in mathematics, which are import for studies in fluid mechanics.

theoretical teaching


practical teaching

In this part of the course, specific problems will be solved. Useful mathematical methods will be explained in that process.

prerequisite

Passed obligatory exams from Mathematics Department.

learning resources

Course handouts.

number of hours

lectures: 35
research: 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: 50
project design: 0
final exam: 50
requirements to take the exam (number of points): 50

references

The Fourier Transform and its Applications, Brad Osgood, Stanford University
Measurements A- Basics

ID: PhD-3315  
teaching professor: Škatarić M. Dobrila  
level of studies: Ph.D. (doctoral) studies  
ECTS credits: 5  
final exam: written

goals

Aim of this course is to provide basic knowledge in measurement techniques to be applied in mechanical engineering. Particularly, how to measure non electrical quantities by electric means. Some basic knowledge in electrical engineering fundamentals can successfully be applied in this course, such as Ohm's low, temperature characteristics of some conductors, variable capacitors and inductance. Depending of particular interest of a group, different measurements cold be scope of course. Both digital and analog techniques are treated, and basic logic elements are presented. Multiplexing and demultiplexing are described, as well as digital computer as a measurement system tool.

learning outcomes

For students, to know how to perform some techniques and how to recognize problem in practice. To understand the principles of specific measurements, and to know how to explain results. To understand someone else measurements and to know how to compare results. To estimate errors and uncertainties of particular measurements. To calibrate equipment; To design experiment with minimizing errors. To achieve a skills for data transmitting, using standard protocols. Physical understanding and experience lead to creative approach in new, unknown situations.

theoretical teaching


practical teaching

Some experiments, depending of student profile (Laboratory)

prerequisite

No specific conditions

learning resources
Electrical engineering laboratory

**number of hours**

lectures: 35
research: 0

**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: 10
final exam: 40
requirements to take the exam (number of points): 40

**references**

Measurement and Instrumentation in Engineering (Dekker Mechanical Engineering) By Francis S. Tse, Ivan E. Morse CRC Press.
Hand out
Measurement techniques in combustion

**ID:** PhD-3275  
**teaching professor:** Stojilković D. Dragoslava  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** oral

**goals**

Introduction to modern techniques of measurement in the field of combustion.

**learning outcomes**

Mastering the modern techniques of measurement in the field of combustion.

**theoretical teaching**

Measurement of the volume and mass flow rate of liquid, gaseous and solid materials, methods and accuracy of each method. Temperature measuring methods and the accuracy of each method. Calculation of adiabatic combustion temperature based on the measured composition of the combustion products. Determination of combustion efficiency, temperature measurement and composition of the gaseous combustion products. Measurement of emission of harmful and dangerous substances from the combustion process, methods, principles and accuracy of each method.

**practical teaching**

Depending on defined topics of doctoral thesis the appropriate program of experimental work on the thesis is adopted.

**prerequisite**

Knowledge of the basics of measurements of fluid flow, temperature and weight measurements. Basic knowledge of thermodynamics and fluid mechanics.

**learning resources**

Instruments for the flue gas analysis.  
Acquisition system for measurement of temperature, pressure, velocity, relative humidity.  
Various sensors for temperature, velocity, relative humidity, pressure.

**number of hours**

lectures: 35  
research: 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: 50
project design: 0
final exam: 40
requirements to take the exam (number of points): 30

references

Mechanics of Ballistic Systems

**ID:** PhD-3416  
**teaching professor:** Micković M. Dejan  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written

**goals**

The acquisition of contemporary knowledge in the field of design of artillery and automatic weapons.

**learning outcomes**

Students acquire advanced knowledge in the field of design of artillery and automatic weapons.

**theoretical teaching**

Design of elements of artillery weapons.  
Design of simple monoblock gun tube, doublelayer gun tube and monoblock gun tube with autofrettage.  
Design of muzzle brakes.  
Design of recoil mechanisms (recuperator, hydraulic recoil brake, hydraulic counterrecoil brake and fluid compensator).  
Design of devices and mechanisms of artillery mounts (cradle, top carriage, bottom carriage arms and equilibrators).  
Design of breechblock mechanism elements for: obturation, triggering and firing, opening, case ejection and closing.  
Design of breech rings.  
Design of automatic weapons: blow back operation systems, recoil operated systems, gas operation systems.

**practical teaching**

Design of elements of artillery weapons - selected examples of calculations.  
Design of simple monoblock gun tube, doublelayer gun tube and monoblock gun tube with autofrettage.  
Design of muzzle brakes.  
Design of recoil mechanisms (recuperator, hydraulic recoil brake, hydraulic counterrecoil brake and fluid compensator).  
Design of devices and mechanisms of artillery mounts (cradle, top carriage, bottom carriage arms and equilibrators).  
Design of breechblock mechanism elements for: obturation, triggering and firing, opening, case ejection and closing.  
Design of breech rings.  
Design of automatic weapons: blow back operation systems, recoil operated systems, gas operation systems.

**prerequisite**

No.
learning resources


number of hours

lectures: 35
research: 0

assessment of knowledge (maximum number of points - 100)

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

references

Mechanics of Bipedal Gait

**ID:** PhD-3124  
**teaching professor:** Lazarević P. Mihailo  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** oral

**goals**

To introduce students to the application of fundamental principles and laws of biomechanics as well as human gait to understand and study human locomotor system (HLS) - prediction of functional motion / movement, human posture. The formation of the corresponding models of bipedal gait, 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**

The student acquires the ability to analyze problems and solutions the ability to predict biomechanical problems of the human locomotor system (HLS) and human gait using scientific methods and procedures as well as computer technology and equipment. Linking the basic knowledge of mechanics, physics, anatomy, physiology with application in biomechanics HLS. Implementation of the laws and the principles of mechanics to anatomical structures; a description of how structure affects on the musculoskeletal human movement, motion; understanding of the strategy of human gait ZMP (zero moment point), CMP (the centroidal moment pivot), analysis of selected motions of healthy people, patients and disabled people.

**theoretical teaching**


**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 human gait: various examples. 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 techniques in biomechanics (FEM,
Matlab,...) with the appropriate application. Biomedical measurements, instrumentation and equipment. Various problems of HLS.
Clinical gait analysis -a case study

prerequisite

none

learning resources

[7] Писани изводи са предавања (handouts),
[8] Cyberbotics Webots - софтверски пакет
[9] MATLAB, Lego Minstorm, софтверски пакети

number of hours

lectures: 35
research: 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: 50
project design: 0
final exam: 50
requirements to take the exam (number of points): 30

references

Mechanics of locomotor system

ID: PhD-3120

teaching professor: Lazarević P. Mihailo

level of studies: Ph.D. (doctoral) studies

ECTS credits: 5

final exam: oral

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

The student acquires the ability to analyze problems and solutions the ability to predict biomechanical problems of the human locomotor system (HLS) using scientific methods and procedures as well as computer technology and equipment. Linking the basic knowledge of mechanics, physics, anatomy, physiology with application in biomechanics HLS. Implementation of the laws and the principles of mechanics to anatomical structures; a description of how structure affects on the musculoskeletal human movement, motion; analysis of selected mechanisms of injury and performance of mechanisms.

theoretical teaching


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 techniques in 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

none

learning resources

[6] Written abstracts from the lectures (Handouts)
[7] Cyberbotics Webots - software simulation package
[8] MATLAB, CATIA, software packages (CSP, SSO)

number of hours

lectures: 35
research: 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: 50
project design: 0
final exam: 50
requirements to take the exam (number of points): 30

references

Mechanics of Nonholonomic Systems

**ID:** PhD-3561  
**teaching professor:** Radulović D. Radoslav  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** oral

**goals**

The goal of this course is to introduce students to the concepts, principles and methods in Mechanics of Nonholonomic Systems to enable practical problems using acquired knowledge of Mechanics of Nonholonomic Systems for monitoring and enable innovation in science and profession.

**learning outcomes**

- to enable students to master terms, methods and principles in Mechanics of Nonholonomic Systems  
- to enable students to relate the knowledge from Mechanics of Nonholonomic Systems with knowledge in other scientific fields, to apply knowledge from Mechanics of Nonholonomic Systems in analysis, synthesis and prediction of solutions and consequences of problems in science.

**theoretical teaching**


**practical teaching**

prerequisite

Defined by the curriculum study of Phd studies program.

learning resources


number of hours

lectures: 35
research: 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: 50
project design: 0
final exam: 50
requirements to take the exam (number of points): 30

references

Mechanics of Variable Mass Systems

ID: PhD-3094

**teaching professor:** Jeremić M. Olivera

**level of studies:** Ph.D. (doctoral) studies

**ECTS credits:** 5

**final exam:** oral

**goals**

-to provide students knowledge of the fundamental principles and methods in Dynamics of variable mass systems
-to enable students to solve practical problems in engineering using acquired knowledge in Dynamics of variable mass systems
-to prepare students to monitoring novelties in science and engineering

**learning outcomes**

-to enable students to master terms, methods and principles in Dynamics of variable mass systems
-to enable students to relate the knowledge from Dynamics of variable mass systems with knowledge in other scientific fields, to apply knowledge from Dynamics of variable mass systems in analysis, synthesis and prediction of solutions and consequences of problems in science

**theoretical teaching**


**practical teaching**


**prerequisite**

Defined by the curriculum study of Phd studies program.

**learning resources**

Trivunac, J., Basic in Dynamics of Reactive Systems, Institut za prostornu tehniku, Beograd, 1968. 18.2. (handouts)

**number of hours**
lectures: 35
research: 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: 50
project design: 0
final exam: 50
requirements to take the exam (number of points): 30

references

Trivunac, J., Basic in Dynamics of Reactive Systems, Institut za prostornu tehniku, Beograd, 1968. 18.2
Mechatronics Systems and Adaptronics

**ID:** PhD-3208  
**teaching professor:** Petrović B. Petar  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written

**goals**

Higher theoretical background for design and practical realization of mechatronics systems, microelectromechanical and optronic systems; New approaches and concepts integration of sensory and control functions into mechanical structure of the system – knowledge on new materials, including multifunctional materials having embedded control and other functions which enables intelligent behavior. Higher theoretical foundations on selforganizing and cognitive systems an implementation of this knowledge on contemporary microprocessor platforms (microcontrollers, digital signal processors and FPGs).

**learning outcomes**

Theoretical knowledge and skills for solving various engineering problems in manufacturing engineering based on multidisiplinary approach, through simultaneously use of knowledge in the field of mechanics, electronics, software and new materials. Knowledge for building of intelligent sensory and actuation systems and their integration into production equipment – automatic and adaptive manufacturing systems, robotic systems an measuring systems.

**theoretical teaching**

Sensors and intelligent systems for signal conditioning, special chapters in optical sensory systems and optronics; Advanced techniques for signal digital processing; Actuation systems, special chapters on actuation systems based on new materials and actuation principles, embedded actuation systems with intelligent functions and behavior; Embedded systems with specialized functional modules and extensive networking functions; Integration of structure (material), actuation and sensory function; New multifunctional and smart materials (piezoceramics, shaped memory alloy, electro - and magnetorheological fluids, etc.); Microelectromechanical systems, including meso and partly nano level (nonlithographic manufacturing processes).

**practical teaching**

Practical teaching is mostly governed by the needs of the student in his doctoral dissertation and takes place in the laboratory.

**prerequisite**

Mechatronics, Dynamics of machines and mechanical systems, Continuous and digital control systems, Cybernetics, Microcontrollers, Soft computing.

**learning resources**

Laboratory for CyberManufacturing Systems at the Department of Production Engineering has extensive experimental resources, which include industrial robots, various sensory and actuation systems, as well as development systems for microcontrollers and related digital
systems.

**number of hours**

lectures: 35
research: 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: 70
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

**references**

Methods for strength testing of pressure equipment

**ID:** PhD-3483  
**teaching professor:** Mitrović R. Nenad  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written

**goals**

Main objective of the course is that students acquire skills and knowledge about experimental methods for strength testing of pressures equipment. Students learn about possibilities of conventional and modern methods for stress and strain measurement (optical methods, strain gauges, extensometers etc.), focusing on three-dimensional optical deformation measurement.

**learning outcomes**

By successful completion of the study program student acquires the following skills: analysis, synthesis and prediction of solutions and consequences in the field of strength testing of pressure equipment; development of critical thinking and self-critical approach; application of knowledge in practice; professional ethics; correlation of knowledge from different fields and their applications; testing of stress and strain states of pressure equipment using conventional and modern methods.

**theoretical teaching**


**practical teaching**

Application of three-dimensional optical deformation measurement method on pressure equipment in laboratory conditions. Development of testing plans. Writing a seminar paper.

**prerequisite**

No requirements.

**learning resources**

Available faculty resources (classrooms, laboratories and library) will be used for the course. Literature for the course is in the professor’s cabinet, as well as at faculty’s library.

**number of hours**

lectures: 35  
research: 0

**assessment of knowledge (maximum number of points - 100)**

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

references

Methods in the design and construction of process equipment

ID: PhD-3203

Teaching professor: Petrović LJ. Aleksandar

Level of studies: Ph.D. (doctoral) studies

ECTS credits: 5

Final exam: written

Goals

Students master the material relating to the stress state in the construction of equipment for pressure testing and qualification of errors and different approaches to construction of pressure equipment and construction of non standard parts and not the usual load of pressure vessels.

Learning outcomes

By mastering the program, students acquire the following skills: analysis, synthesis and forecasting solutions and consequences, the development of critical and self-critical thinking and approach, application of knowledge in practice; overcome substance that is related to stress states in the construction of equipment for pressure testing and qualification errors.

Theoretical teaching


Practical teaching

Student prepares research paper. Instruction and preparation for the seminar work carried out through the analysis of different types of activities. It includes the results of tests and measurement analysis of issues that needs to be solved, obtaining literature and its analysis.

Prerequisite

Attendance requirement is defined by the interest of candidates and dissertation topic

Learning resources

Subject to available resources are used at the university, which include Classroom space, laboratory facilities and library. Literature is meant the subject teacher in the office and the library faculty.

Number of hours

Lectures: 35

Research: 0
assessment of knowledge (maximum number of points - 100)

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

references

Sokolov, V.I., Fundamentals and rasčeta konstruirovania mašinja and aparatov , Mašinostroenine, Moscow, 1983
Methods of Energy Planning

**ID:** PhD-3528  
**teaching professor:** Stevanović D. Vladimir  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** seminar works

**goals**

Application and development of methods for planning of energy use and development of energy systems in towns, regions and states.

**learning outcomes**

Application and development of statistical, economy and phenomenological methods and models for the energy planning and development of energy systems.

**theoretical teaching**


**practical teaching**

Development of a model for the planning of energy consumption and development of an energy system.

**prerequisite**

Passed exam in Thermodynamics at Bachelor or Master studies.

**learning resources**

Lecture notes, in-house and other available codes for planning of energy consumption.

**number of hours**

- lectures: 35  
- research: 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: 60  
- project design: 0  
- final exam: 30
requirements to take the exam (number of points): 0

references

Energy - The International Journal, Elsevier,
http://www.sciencedirect.com/science/journal/03605442
Microchannel fluid flow

**ID:** PhD-3267  
**teaching professor:** Stevanović D. Nevena  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written

**goals**

The aim of this subject is getting knowledge about specific phenomena which occur in the fluid flow in micro systems as well as about scientific and mathematical methods that allow obtaining analytical and numerical solutions for prediction, analysis and research gas and liquid flow in channels whose characteristic dimensions are of the order of micrometers.

**learning outcomes**

Students are qualifying for computing pressure, velocity and temperature field in micro structure fluid flow and analyzing the effects of different flow conditions and boundary conditions on them with contemporary scientific and mathematical methods. Also, they qualify to recognize specific phenomena which appears in microdevices fluid flow due to the large surface to volume ratios and to coupling of flow with heat and mass transport as well as electromagnetic fields.

**theoretical teaching**

Theoretical lessons incorporates applications of the fundamental laws (mass, momentum, and energy) that govern fluid mechanics in order to solve and model gas and liquid flow in the microchannels, application of the boundary conditions characteristic for the gas flow in the microsistem i.e. slip, thermal creeping and temperature jump at the boundary, introducing with electrokinetic’s phenomena which occur in liquid microchannel flow and mathematical modelling surface tension driven flows i.e. electrophoresis and electro-osmotic flow.

**practical teaching**

Practical lessons contains: application of the basic fluid mechanics equations for the solving analytical and numerical solutions for the modeling fluid flow in the micro structures which include different effects as rarefaction, slip, thermal creeping, temperature jump at the wall, electro-hydrodynamic phenomena as the electric double layer and creating and solving mathematical models for electro kinetic and electroosmotic flows.

**prerequisite**

Passed exam in Fluid mechanic.

**learning resources**

Course handouts.

**number of hours**

lectures: 35  
research: 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: 50
project design: 0
final exam: 50
requirements to take the exam (number of points): 30

references

Stevanović, N., Fluid flows in microdevices, Faculty of Mechanical Engineering, Belgrade, 2010.
Model and prototype testing of hydraulic machinery

ID: PhD-3438  
teaching professor: Božić O. Ivan  
level of studies: Ph.D. (doctoral) studies  
ECTS credits: 5  
final exam: seminar works

goals

Achieving scientific competence in the fields of experimental tests of hydraulic machinery models and prototypes.  
Mastering theoretical and practical knowledge in the fields of specific measurements in relation to hydraulic machinery characteristics research.  
Obtaining necessary knowledge for the individual research in laboratory and in situ (hydropower stations) with the aim of hydraulic machines complex tests.

learning outcomes

Obtaining necessary measurements knowledge for research of flow processes in the hydraulic machines and for determination of their characteristics.  
Knowledge of test rigs configurations, contemporary measuring methods, techniques and devices for specific measurements in hydraulic machinery.  
Ability to do specific integral flow parameters determination in the hydraulic machines by the experimental measurements and by the numerical simulations and their mutual comparative analysis.  
Having the relevant know-how for individual scientific research in laboratory for hydraulic machinery testing.

theoretical teaching

Main and specific characteristics of hydraulic machinery (turbines, pumps and pump-turbines). Methodologies, standard procedures and activities for energy and cavitation characteristics determination of hydraulic machinery models. Test rigs configurations. Measurement devices and calibrations. Laboratory and on-site dimensional checks of the hydraulic machinery flow passages. Physical properties measurements with aim to determine machinery characteristics. Accuracy, repeatability and stability during measurement. Measuring data analysis. Experimental analysis of the model (pressure fluctuations measurements and cavitation observations). Specific researches. Experimental identification of 3D flow structure in hydraulic machinery passages. Comparative analysis of characteristics obtained by numerical and experimental research. Scale effects. On-site measuring methods and special research of hydraulic machines prototype.

practical teaching

Research in laboratory for hydraulic machines testing. Preparation and organization of measurements, testing, specific research data acquisition and analyses.

prerequisite

No prerequisites for attending this subject.

learning resources
Test rigs in laboratory. Measuring devices. Printed material and hand-outs.

**number of hours**

lectures: 35  
research: 0

**assessment of knowledge (maximum number of points - 100)**

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

**references**

Мирослав Бенишек „Хидрауличне турбине“, Машински факултет у Београду, 1998  
Иван О. Божић „Хидрауличне турбине - Практични примери са изводима из теорије“,  
Машински факултет у Београду, 2017
Modeling of Turbulent Flows

ID: PhD-3501
Teaching professor: Ćočić S. Aleksandar
Level of studies: Ph.D. (doctoral) studies
ECTS credits: 5
Final exam: written

Goals

To develop and rationalize principles of physical and mathematical modelling of turbulent flows and to understand the applications and limitations of standard turbulent models.

Learning outcomes

Student will gain knowledge in turbulence modelling and its application, and also understand the limitations of specific turbulent models in some types of turbulent flows.

Theoretical teaching


Practical teaching

Detailed discussion of themes from the lectures, with characteristic examples. Application of OpenFOAM software for calculation of characteristic turbulent flows like turbulent flow in channel and, backward facing step, etc.

Prerequisite

Passed exam "Fluid Mechanics-D" and "Turbulent flows"

Learning resources

Computer classroom SimLab.

Number of hours

Lectures: 35
Research: 0

Assessment of knowledge (maximum number of points - 100)

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

references

Modelling of Composite Material Micromechanics

ID: PhD-3515
teaching professor: Balač M. Igor
level of studies: Ph.D. (doctoral) studies
ECTS credits: 5
final exam: seminar works

goals

Learn the fundamental principles of the modeling of non isotropic materials. Apply these principles to proper modeling multi-directional fiber composite as well as particulate composite materials based on properties of composite constituents. Examine basic issues associated with the design of these composite materials for various applications. Learn methods of computer modeling of composite structures in FEM based software.

learning outcomes

1. Students can determine the elastic constants and strength of different types of composites, for given constituent properties, volume fraction and distribution of reinforcement.
2. Students are capable to make different types of micromechanical models of porous (optional) and non porous composites based on properties of composite constituents.
3. Students can, using FEM, numerically model different types of composites for various applications based on individual properties of the reinforcement and the matrix.
4. Students have developed a basic understanding of load transfer between matrix and reinforcement.

theoretical teaching

1. Introduction to micromechanics of composite materials - Volume and mass fractions, distribution of reinforcement, density and void content.
2. Evaluation of composite elastic moduli: Representative volume element (RVE) - elementary mechanics of material models.

practical teaching

-

prerequisite

Taken exams:
Strength of materials,
The base of strength of constructions,
Basics of composite materials mechanics or Composite materials mechanics.
learning resources

The whole course material is well covered by hand-outs written by the lecturers of the course. Every attendee of the course will be provided his/hers own copy of the hand-outs. Apart of this, all the below mentioned books can be borrowed from the lecturers during the course or ordered on some relevant websites. Moreover, significant number of scientific papers covering listed topics are available.

number of hours

lectures: 35
research: 0

assessment of knowledge (maximum number of points - 100)

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

references

"Mechanics of composite materials", Autar K. Kaw
"Mechanics and analysis of composite materials", Valery Vasiliev and Evgeny Morozov
"Mechanics of composite materials", Robert M. Jones
"Principles of composite materials mechanics", Ronald F. Gibson

Modelling of thermalhydraulic transients

**ID:** PhD-3264  
**teaching professor:** Stevanović D. Vladimir  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** seminar works

**goals**

The aim of the subject is developing skills for the simulation and analyses of thermalhydraulic transients in complex pipeline networks and components of energy plants.

**learning outcomes**

Students are trained to develop mathematical models of thermalhydraulic transients, to solve these models with analytical and numerical methods and to conduct simulation and analyses with the aim of safety evaluations of energy plants, as a support to the design of control and safety systems and to the defining of operational procedures.

**theoretical teaching**

Developing of the lumped parameters models of two-phase gas-liquid systems with phase transitions, one-dimensional compressible flows of one-phase and two-phase fluids, and multidimensional conduction and one-phase and two-phase flows in multidimensional space. Numerical methods for the solving of the system of ordinary differential equations, the method of characteristics for the solving of the system of hyperbolic partial differential equations, and control volume methods for the solving of parabolic and elliptic partial differential equations.

**practical teaching**

Computer simulations of dynamical pressure changes in steam accumulators and pressurizers applied in the district heating systems and nuclear steam supply systems. Computer simulations of gas pipeline, district heating system and steam generator transients.

**prerequisite**

Attended courses in Fluid Mechanics, Thermodynamics and Numerical methods within master or doctoral studies.

**learning resources**

Course handouts.  
Computer equipment.  
Software for numerical solving of systems of differential equations of various types.  
Software for simulation and analyses of pressure transients in pipeline networks and pressurized vessels.  
Software for simulation and analyses of multidimensional two-phase flows.

**number of hours**
lectures: 35
research: 0

assessment of knowledge (maximum number of points - 100)

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

references

Stevanovic, V., Thermal-Hydraulics of Steam Generators – Modelling and Numerical Simulation, University of Belgrade, Faculty of Mechanical Engineering, 2006.
Modelling, optimisation and forecasting in Industrial engineering

ID: PhD-3022

teaching professor: Bugarić S. Uglješa

level of studies: Ph.D. (doctoral) studies

ECTS credits: 5

final exam: written

goals

Achieving competency and enhancement of gained knowledge in academic studies in fields of modelling, optimisation and forecasting for needs and implementation in Industrial engineering, as well as development of creative skills and overwhelm with practical skills needed for professional practice in solving real world problems of Industrial engineering.

learning outcomes

Curriculum overcome enables coverage of overall skills as analysis and synthesis of real world problems in industry using mathematic tools underlying: modelling (mathematical modelling of real world system), optimisation (gaining optimal configuration of real world system) and forecasting (work of real system in future).

theoretical teaching

Modelling – What is mathematical modelling ? (or how to translate our beliefs about how the world functions into the language of mathematics). Division of mathematical models (deterministic, stochastic). Range of objectives obtained using mathematical modelling (developing scientific understanding, test the effect of changes in a system, aid to decision making).

Optimisation – Optimisation as an mathematical discipline. Finding of minimal and maximal values of goal functions subject to constrains. Overview of optimisation methods.

Forecasting – Time series, Forecasting methods, Forecasting errors, Regression analysis (linear regression, method of least squares), Forecasting in practice.

practical teaching

Selection of real world industrial system connected with candidate research, which should be used as a basis for system modelling, optimisation and forecasting.

prerequisite

Students should have (but not necessary) a background in statistics, system engineering, mathematics, computer science.

learning resources

4. Software: QSopt Version 1.0 (Linear programming problems).
7. Personal computers.

**Number of hours**

- Lectures: 35
- Research: 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: 70
- Final exam: 30
- Requirements to take the exam (number of points): 0

**References**

Modern biomedical and dental devices

**ID:** PhD-3058  
**teaching professor:** Sedmak S. Aleksandar  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** oral

**goals**

Introducing students to the application of different biomaterials and devices in order to understand and study their functional behaviour in contact with the human body. Analysis of the connections between the biomaterial and the body system, in order to ensure reliable implant operation. Review of the procedures and methods used in biomedical engineering for development and examination of implants. Review of modern medical and dental devices and its possibilities of application. Application of standards in biomedical engineering. Sterilization Methods for devices and implants in medicine and dentistry. The potential co-operation with experts in the field of materials science and medicine is allowed, which provides the ability to work in specialized laboratories and clinical facilities.

**learning outcomes**

By attending this course the student will master the application of biomaterials and devices in medicine and dentistry, using modern scientific methods. Students gain insight into the standards for the testing and development of biomaterials and implants, and standards for the development and application of medical and dental devices. Theoretical considerations, laboratory experimental work and the application of numerical analysis using the licensed software for finite element method, enables the synergy of the previously acquired knowledge in physics, materials science, mathematics and mechanics, in order to implement them in engineering practice.

**theoretical teaching**


**practical teaching**

Examples of applications of biomaterials in the design, development and exploitation of structures used in medicine and dentistry. Examples and solutions of implants that are made from biomaterials, known from the Biomaterials 1 course. Experimental Methods In Vitro and

prerequisite

-  

learning resources

[1] Written lectures (handouts)  
[2] Excerpts from the standard  

number of hours

lectures: 35  
research: 0

assessment of knowledge (maximum number of points - 100)

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

references

Modern Combustion Appliances

ID: PhD-3318  
teaching professor: Adžić M. Miroljub  
level of studies: Ph.D. (doctoral) studies  
ECTS credits: 5  
final exam: written

goals

To familiarize the students with the state-of-the-art combustion technologies and combustion systems.

learning outcomes

Encouragement of the students to apply the state-of-the-art combustion technologies and combustion systems in practice.

theoretical teaching

1. Introduction.  
2. New achievements in combustion.  
3. Environmental protection.  
4. Free space combustion.  
5. Fluidized bed combustion.  
7. Flameless combustion.  
8. Preparation of fuels.  
10. Modern combustion equipment.  
11. Combustion and environmental protection.  

practical teaching

n/a

prerequisite

No preconditions for attendance

learning resources

number of hours

lectures: 35  
research: 0

assessment of knowledge (maximum number of points - 100)

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

references

Adžić M. Handouts
Modern concepts of organizations

ID: PhD-3152

**teaching professor:** Milanović D. Dragan

**level of studies:** Ph.D. (doctoral) studies

**ECTS credits:** 5

**final exam:** written

**goals**

Researching and studying the state of the company and applying modern concepts of organization.

**learning outcomes**

Upon the successful completion of this course, students should be able to:
- discuss the modern theory of organization,
- distinguish between complex problems in organizations,
- select the models of organization functioning,
- apply the modern concepts of organizations,
- solve complex problems of organizations,
- evaluate the modern concepts of organizations.

**theoretical teaching**

1. The modern theory of organization
2. The contingency theory of organization
3. Khandwalla's model of functioning of organization
4. Mintzberg’s organizational configurations
5. Burton and Obel's contingency model.
6. Use of OrgCon software package in diagnosis of organization
7. Donaldson’s non-contingency theory
8. Types of organizational structures in modern theory of organization
9. Organizational change. Diagnosis and management of organizational change.
10. A case-study example of analyzing the state of organization in a specific company
11. The possibility of implementation of modern concepts of organization in companies

**practical teaching**

A case-study from the field of diagnosis of the state of organization in a company and application of modern concepts of organization.

**prerequisite**

Students should be enrolled in the second year of doctoral studies.

**learning resources**

**number of hours**

- lectures: 35
- research: 0

**assessment of knowledge (maximum number of points - 100)**

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

references

Multiphase flow

**ID:** PhD-3303  
**teaching professor:** Crnojević Đ. Cvetko  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written+oral

**goals**

- Due to the presence of fluid in the secondary phase, the second fluid or solid particle, a volume concentration change how the physical properties of the fluid and the appropriate balance equations.
- Introduction to the phenomena of presence in the fluid of the second fluid or solid phase.
- Getting to know the theoretical analysis and experimental methods for the study of many problems multiphase flow.

**learning outcomes**

Acquiring skills and mastery of theoretical and numerical methods necessary to analyze different types of multiphase flow.

**theoretical teaching**


**practical teaching**

- Laboratory exercise of fluidization.  
- CFD simulation of multiphase flow.

**prerequisite**

No special requirements.
learning resources

number of hours

lectures: 35
research: 0

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 23
laboratory exercises: 2
calculation tasks: 0
seminar works: 0
project design: 0
final exam: 70
requirements to take the exam (number of points): 0

references
Nanomechanical Characterization of Materials

**ID:** PhD-3513  
**teaching professor:** Balać M. Igor  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** seminar works

**goals**

Learn the fundamental principles of nanomechanical characterization of isotropic materials. Apply these principles to proper understanding experimental results obtained for different types of materials. Examine basic issues associated with proper preparation of these materials for nanomechanical surface characterization. Learn different methods for quick proper separation of obtained results.

**learning outcomes**

1. Student can understand fundamental principles of nanomechanical characterization of isotropic materials.  
2. Student are capable to apply mathematical funcional as description of loading and unloading curve.  
3. Student can analyze loading and unloading curve in order to separate "bad" results from "good" ones.  
4. Students have developed a basic understanding of load and unload process with problems associated with it.  
5. Students are capable to prepare sample for nanoindentation experiment, conduct experiment and read results in proper way.

**theoretical teaching**

1. Nanoindentation: main idea and instrumentation.  
2. Introducing load-displacement curve.  
3. Olivier-Pharr method.  
4. Sink-in, Pile-ups and Joslin-Olivier method.  
6. The role of grain boundaries and interfaces.  
7. Nanoindentation with ultralow forces; nanoindenting with Atomic Fore Microscope - AFM.  
8. Applications.

**practical teaching**

1. Introducing Hysitron nanoindenter.  
4. Sample measurement.

**prerequisite**

- 

**learning resources**
The whole course material is well covered by hand-outs written by the lecturers of the course. Every attendee of the course will be provided his/hers own copy of the hand-outs. Moreover, significant number of scientific papers covering listed topics are available.

**number of hours**

lectures: 35  
research: 0

**assessment of knowledge (maximum number of points - 100)**

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

**references**
Neural Networks and Fuzzy Systems

ID: PhD-3552

teaching professor: Jovanović Ž. Radiša

level of studies: Ph.D. (doctoral) studies

ECTS credits: 5

final exam: written

goals

This course is intended to provide students with an in depth understanding of the fundamental theories and learning methods, as well as advanced issues of neural networks and fuzzy logic systems. After the course, the students will be able to apply the learned knowledge to solve problems in their respective research fields.

learning outcomes

• Understanding of fundament theories, learning methods and advanced issues of neural network and fuzzy systems.
• Be able to apply the learned knowledge of neural and fuzzy systems to solve various research problems.

theoretical teaching


practical teaching

PA:

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

PL:

Practice and experiments: computer applications in simulation and implementation of neural networks and fuzzy systems, as well as their practical realization using Matlab/Simulink and different plants within a modular educational real-time control system (inverted pendulum, ball and beam system, DC servo motor, coupled tanks experiment, heat flow experiment).

prerequisite

Defined by curriculum of the study programme.

learning resources

• Modular educational real time control system with various plants (DC servo motor, inverted pendulum, double inverted pendulum, heat flow experiment, coupled water tanks experiment), with acquisition hardware and software.
number of hours

lectures: 35
research: 0

assessment of knowledge (maximum number of points - 100)

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

references

Nonlinear Digital Control Systems

ID: PhD-3025

**teaching professor:** Bučevac M. Zoran

**level of studies:** Ph.D. (doctoral) studies

**ECTS credits:** 5

**final exam:** seminar works

**goals**

Mastering with: techniques for analysis and synthesis of nonlinear digital control systems

**learning outcomes**

Knowledge of the techniques for analysis and synthesis of nonlinear digital control systems.

**theoretical teaching**

Practical Aspects of the system with different types of modulation, and quantization due to the level. Mathematical modeling of frequency and width modulated systems, and systems quantized due to the level. Transient processes. Dynamic properties. Methods of analysis and design (Lyapunov method).

**practical teaching**

- Direct tracking of the course theory through the illustrative examples,
- Define and elaborate of the task of seminar paper,
- Consultation.

**prerequisite**

There are no requirements.

**learning resources**

- Manuscript at http://au.mas.bg.ac.rs/Nastava-Kau/Nastava_Download.htm
- Видаль П., Нелинейные импульсные системы, Перевод с французского Б. Ю. Мандровского-Соколова, Под ред. В. М. Кунцевича, Энергия, Москва, 1974.
- Digital computer.

**number of hours**

- lectures: 35
- research: 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: 70
- project design: 0
- final exam: 30
requirements to take the exam (number of points): 30

references

Видаль П., Нелинейные импульсные системы, Перевод с французского Б. Ю. Мандровского-Соколова, Под ред. В. М. Кунцевича, Энергия, Москва, 1974.
Кунцевич, В. М., Чеховой, Ю. Н., Нелинейные системы управления с частотно- и широтно-импульсной модуляцией, Издательство „Техника”, Киев, 1970.
Non linear Finite Element Methods

ID: PhD-3511
teaching professor: Buljak V. Vladimir
level of studies: Ph.D. (doctoral) studies
ECTS credits: 5
final exam: written

goals

The objective of this course is to provide a comprehensive introduction to the methods and theory of nonlinear finite element analysis. The focus is given to the formulation and solution of the discrete equation for various classes of problems that are of principal interest in applications in solid mechanics and structural mechanics. In the introductory part of the course the discretization by finite elements of continua in one-dimension and in multi-dimension is presented. Discrete equations are developed for Lagrangian meshes, and different strategies for the solution of nonlinear problems are discussed. In problems of large displacements, the differences between total and updated Lagrangian formulations are demonstrated. Further on, the material nonlinearity is covered by introducing the formulation of constitutive equations for plasticity and behavior in large deformation regime. The course has an engineering style rather than a mathematical, although it includes analyses of the stability of numerical methods, as the objective is to teach methods of finite element analysis and the properties of the solution.

learning outcomes

After fulfilling this course the students will be able to:
-Understand and successfully use strategies for solving various nonlinear problems by methods that are implemented in most modern commercial FEM software.
-Write their own code for iterative solution of nonlinear FEM problems in FORTRAN or MATLAB surrounding.
-Will gain full understanding of implementation of nonlinear constitutive models into the algorithms for numerical solutions of boundary value problems.
-Will be capable to develop their own sub-routines written in FORTRAN for specific material constitutive models which can be used within commercial FEM software.

theoretical teaching

Theoretical concepts of nonlinear methods and their implementation will be presented within theoretical lectures. Since a fundamental understanding of the equations requires substantial familiarity with continuum mechanics, the lectures will summarize the continuum mechanics which is pertinent to the topics taught in the course. Strategy solutions for given problems are fully derived on one dimensional elements and the concept is then extended to the multi dimensional elements.

practical teaching

Each topic covered is thoroughly demonstrated by numerical examples. Practical part of the course includes implementation of discussed strategies into fully working computer programs in MATLAB or FORTRAN surrounding. The use of discussed methods is evidenced and exemplified in commercial FEM software ABAQUS. Students will get familiar with using of such software for performing advanced nonlinear structural analysis.
prerequisite

Knowledge of basic FEM concepts and basic knowledge of structural analysis are required.

learning resources

2. Introduction to computational plasticity. Fionn Dunne and Nik Petrinic.

number of hours

lectures: 35
research: 0

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 0
laboratory exercises: 5
calculation tasks: 5
seminar works: 40
project design: 0
final exam: 50
requirements to take the exam (number of points): 30

references
Non-linear strength problems of rail vehicles

ID: PhD-3568
teaching professor: Milković D. Dragan
level of studies: Ph.D. (doctoral) studies
ECTS credits: 5
final exam: seminar works

goals

1. Deepening of knowledge in different areas of non-linear strength problems of rail vehicles.
2. Become acquainted with advanced methods and tools for the study of non-linear strength problems of rail vehicles.
3. Training for participation in research and development teams on the projects of rail vehicles and their systems.

learning outcomes

After completion of the course a PhD student should be able to:

1. Apply advanced computational methods and computer tools in calculation of non linear strength problems of railway vehicles.
3. Participates in defining the research programs of rail vehicle strength problems.
4. Participate in the critical evaluation of research results.
5. Participate in drawing conclusions about the quality of the research results.
6. Participate in proposing future research directions of specific strength problems of the railway vehicles.

theoretical teaching

Depending on PhD. thesis field following subjects will be more or less deeply studied.
Nonlinear modeling in the field of rail vehicles strength. Specific tools for calculations in different areas of the nonlinear strength.
Elastic elastomeric elements modeled in hiperelasticity area. Methods for determining material properties.
Material models in elasto-plastic area. Collision scenarios in rail traffic. Structural strength requirements that should be fulfilled in different collision scenarios. Types of elements for the kinetic energy absorption in collision of railway vehicles. The concept of vehicle headparts in order to reduce the consequences of a collision.
Residual stresses due to braking of railway wheels. Measures to reduce the risk of wheel fracture. Fracture toughness and its measurement methods on samples from the wheels of rail vehicles. Modeling the formation process of residual stresses during braking with brake shoes. Methods for measuring the residual stress. Methods for repairing wheels with unacceptably high residual stresses.

practical teaching

Student writes seminar paper from a selected area upon agreement with relevant lecturer and supervisor of doctoral dissertation.

prerequisite
Knowledge of the railway vehicles design at the master level course. Completed course of the strength of material at the master level.

**learning resources**

Milutinović, D., Simić, G., Load and calculations of the railway vehicles wheels, Faculty of Mechanical Engineering, Belgrade 2006
Simić, G. Railway vehicles, Faculty of Mechanical Engineering, Belgrade 2013
Milković, D., Wayside systems for wheel-rail contact forces measurements, Faculty of Mechanical Engineering, Belgrade 2017
Tanasković J., Passive safety of railway vehicles, Faculty of Mechanical Engineering, Belgrade 2014

Publications from the SCI list

**number of hours**

lectures: 35
research: 0

**assessment of knowledge (maximum number of points - 100)**

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

**references**

ERRI Reports
Nonplanar Lifting Surfaces

**ID:** PhD-3376  
**teaching professor:** Kostić A. Ivan  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written

**goals**

The goal is that after attended course in Nonplanar Lifting Surfaces, students become familiar with the specific issues considering applications of different types of nonplanar wing and tail planforms, wingtips and wingtip devices, aimed to improve the overall aerodynamic efficiency of modern flying vehicles. Students will get acquainted with the contemporary CDF tools, which can be efficiently applied for such kind of aerodynamic analysis and design.

**learning outcomes**

After accomplishing the course, students will acquire the knowledge in the specific domains of nonplanar lifting surface aerodynamics. They will be able to rationally select, configure and perform basic optimizations of different aerodynamic devices, that would lead to the increased overall aerodynamic efficiency of a given aircraft.

**theoretical teaching**


**practical teaching**

None.

**prerequisite**

None.

**learning resources**

Lectures in electronic form, the demo movies and clips, and graphical simulations available through the virtual workshop (program MOODLE), internet resources. Vlaero CFD software.

**number of hours**

lectures: 35  
research: 0

**assessment of knowledge (maximum number of points - 100)**

feedback during course study: 0  
test/colloquium: 20
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 50
final exam: 30
requirements to take the exam (number of points): 21

references

Nuclear Power Plants Safety

**ID:** PhD-3526  
**teaching professor:** Stevanović D. Vladimir  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** seminar works

**goals**

Simulation and analyses of nuclear power plant transients and accidents that might lead to or result into jeopardizing plant safety and environment, such as small and large loss of coolant accidents, station black-out, nuclear reactors power excursions and other accidents, including analyses of active and passive safety systems.

**learning outcomes**

Development and application of thermal-hydraulic models for computer simulations and analyses of nuclear power plant transients and accident conditions. Analysing efficiency of safety systems in mitigating consequences of plant abnormal conditions on environment.

**theoretical teaching**


**practical teaching**

Development of a thermal-hydraulic model and a computer code for the simulation of behaviour of a chosen nuclear power plant component or system. Application of the developed model and code to the safety analyses.

**prerequisite**

Passed exams in Thermodynamics, Fluid Mechanics and Higher Mathematics at Bachelor or Master university studies.

**learning resources**

Lecture notes, computer equipment, in-house and commercial computer codes for two-phase flow simulations.

**number of hours**

lectures: 35  
research: 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: 60
project design: 0
final exam: 30
requirements to take the exam (number of points): 0

references

Stevanovic, V., Thermal-Hydraulics of Steam Generators – Modelling and Numerical Simulation, University of Belgrade, Faculty of Mechanical Engineering, 2006.
Numerical methods

**ID:** PhD-3259  
**teaching professor:** Spalević M. Miodrag  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** oral

**goals**

Fundamental knowledge and understanding of methods in numerical mathematics. Qualifying of students for solving of problems in this area by using scientific acts and methods. Ability to follow contemporary achievements in the area of numerical mathematics and its applications, especially in technique and Engineering. Realization of numerical methods by using the program systems Matlab, Mathematica.

**learning outcomes**

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

- They are skilled in solving mathematical models, resulting in problem solving in science, technic and engineering sciences, by methods of numerical mathematics in approximation theory, numerical differentiation and integration, the theory of iterative processes, numerical linear algebra, numerical solution of differential equations.
- Locate errors that occur in the process of calculation, following their spreading and apply the knowledge gained in the construction of stable numerical methods.
- Manage with implementation of numerical methods in MATLAB programming system.
- Monitor contemporary achievements in the field of numerical mathematics and its applications, particularly in technic and engineering sciences.

**theoretical teaching**


**practical teaching**


**prerequisite**

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

**learning resources**


2. G.V. Milovanović, M. Kovačević, M. Spalević, Numerical mathematics - Collection of solved problems, University of Niš, 2003 (http://mat.mas.bg.ac.rs)

3. G.V. Milovanović, Numerical analysis, Parts 1, 2, 3, Naučna knjiga, Beograd, 1991


9. S. Larsson, V. Thomee, Partial Differential with Numerical Methods, Springer, 2005

10. Software Matlab

11. Software Mathematica


**number of hours**

lectures: 35
research: 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: 60
project design: 0
final exam: 30
requirements to take the exam (number of points): 0

**references**

S. Larsson, V. Thomee, Partial Differential with Numerical Methods, Springer, 2005
Numerical simulation of IC Engines processes - Advanced approach

**ID:** PhD-3421  
**teaching professor:** Popović J. Slobodan  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written

**goals**

The goal of the course is to acquaint students with the types of mathematical models of engine working process and all aspects of so-called "zero-dimensional" model of engine real cycle. Mathematical modeling and computer simulation of working cycle have important role in engine design optimization and improvement of engine performances, energetic and ecological characteristics.

Acquiring new knowledge on role and importance of modelling dynamic processes in IC Engines. Broadening theoretical knowledge and analytical approach to thermodynamics, heat and mass transfer, fluid mechanics and fuel combustion by studying dynamic processes in IC Engine cylinder and collectors. Broadening knowledge and skills in applied computational methods and modular programming. Developing practical skills to design complex model structures and apply extensive and efficient numerical methods for studying and research of IC Engine dynamic processes.

**learning outcomes**


**theoretical teaching**

1. Importance of mathematical modeling and computer simulation of engine working process for engine design optimization and improving of engine performances, energetic and ecological characteristics.
2. Basic differential equations of so called "zero-dimensional" model of real working cycle for engine cylinder as open thermodynamical system based on first and second lows of thermodynamic and low of mass conservation.
5. Modeling of engine combustion process (heat release). Types of engine heat release models. The model engine heat release based one stage and two stage Wiebe functions and the correlation of Viebe function parameters with engine type and engine speed and load. "Quasi-dimensional" models of engine heat release: model of turbulent flame front propagation for spark ignition engines; model of multi-zone combustion in fuel spray for diesel engines "model Hiroyasu".
7. Experimental testing of engine working process: recording of in-cylinder pressure history;
identification of model non sufficient known parameters; verification of cycle simulation results based on experimental results.

**practical teaching**

1. Cylinder model structure development – Demonstration and Analysis of different models
2. Properties of the working fluid – Demonstration and comparative analysis, empirical models and chemical equilibrium
3. Wiebe single & multi-stage parametric combustion model, flame propagation models, Hiroyasu model
4. Heat transfer models – Demonstration and comparative analysis of different models
5. Gas dynamics – Model structure development, analysis and demonstration using commercial software packages
6. Student project task –SI/CI IC engine simulation model development
7. Laboratory Task: - In-cylinder pressure measurement and combustion analysis

**prerequisite**

Passed exam in Numerical methods. Good practical knowledge of Matlab/Simulink

**learning resources**

Mathworks Matlab/Simulink IDE (Licenced)
Ricardo WAVE – 1D Engine and gas dynamics simulation software package (Licenced)
LMS Imagine.Lab AMESim – Simulation software for modelling and analysis of 1D systems (Licenced)
Laboratories equipped with IC Engine testing equipement (fully equiped IC Engine test benches)
DAQ Measurement equipement (National Instruments PXI based system with Labview Developement software)

**number of hours**

lectures: 35
research: 0

**assessment of knowledge (maximum number of points - 100)**

feedback during course study: 0
test/colloquium: 0
laboratory exercises: 10
calculation tasks: 0
seminar works: 60
project design: 0
final exam: 30
requirements to take the exam (number of points): 50

**references**
Numerical simulation of welding processes

**ID:** PhD-3251  
**teaching professor:** Sedmak S. Aleksandar  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** oral

**goals**

Understanding the basic principles of welding technology as a prescribed course of action to be followed when making a weld. Introducing students to techniques of material selection, preparation, preheating, methods and control of welding and subsequent thermal treatment. Introducing students to the application of numerical methods in analysis and simulation of welding processes. Understanding and studying the problem of coupled external load of welded structures. The development of independent and practical work using licensed software.

**learning outcomes**

By attending the course the students are mastering the basic knowledge of welding technology. Theoretical considerations and computational examples enable the student to master all the necessary principles of welding technology needed for the manufacture of welded joints. Introducing students to current modern standards and recommendations in this field. By attending this course students will master advanced use of finite element method, especially in the field of welding and welded structures. Theoretical considerations, computational examples and work by using licensed software, enables students to link previously acquired knowledge of mathematics, mechanics, construction and mechanical resistance of materials for application in engineering practice.

**theoretical teaching**


**practical teaching**

Solving exercises in specification of welding technology - examples include various types and thicknesses of the base metal, welding process and position. Solving exercises in qualification of welding technology - examples include various types and thicknesses of the base metal, welding process and position. Constitutive expression of non-linear material behavior. Examples of formulations in the FEM. The formation of the real stress - strain curve. Special cases. Development of FEM models of welded joints and elastic-plastic analysis. Design of a FEM model of the welded joint and the elastic-plastic analysis. The application of different

prerequisite

- 

learning resources

[1] Written lessons from lectures (handouts)

number of hours

lectures: 35
research: 0

assessment of knowledge (maximum number of points - 100)

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

references

Numerical Structural Analysis

**ID:** PhD-3255  
**teaching professor:** Simonović M. Aleksandar  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written

**goals**

Study of theoretical backgrounds and applying of advanced structural numerical analysis methods. Development of creative abilities for R&D and specific engineering problems approach using advanced structural numerical analysis methods.

**learning outcomes**

Vast and comprehensive field of structural analysis problems is covered with contemporary numerical methods of structural analysis. Advanced Numerical methods for structural analysis included enable extended analysis of structures of various types and materials.

**theoretical teaching**


**practical teaching**

Contents of exercises follows the exposed material.

**prerequisite**

There is no necessary requirement for attendance of Numerical Structural Analysis.

**learning resources**

Simlab - computer laboratory

**number of hours**

<table>
<thead>
<tr>
<th>Lectures</th>
<th>Research</th>
</tr>
</thead>
<tbody>
<tr>
<td>35</td>
<td>0</td>
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</tbody>
</table>

**assessment of knowledge (maximum number of points - 100)**

- Feedback during course study: 0
- Test/colloquium: 0
- Laboratory exercises: 0
- Calculation tasks: 0
- Seminar works: 70
- Project design: 0
final exam: 30
requirements to take the exam (number of points): 0

references

G.R. Liu, V.B.C. Tan, X. Han, Computational Methods Part 1, - Springer 2006.
G.R. Liu, V.B.C. Tan, X. Han, Computational Methods Part 2, - Springer 2006.
Operating Systems in Mechatronics

ID: PhD-3224

**teaching professor:** Radojević LJ. Slobodan

**level of studies:** Ph.D. (doctoral) studies

**ECTS credits:** 5

**final exam:** written+oral

**goals**

The aim of the subject is to introduce a PhD student with some algorithms that are typical for programming operating systems Mechatronic devices. In this case, the typical algorithms for autonomous robotic Mechatronics systems. These algorithms have a basic feature: through time they are online.

**learning outcomes**

The doctoral candidate will identify processes that are characteristic of Mechatronics systems and processes at the same time operating system. Also, the doctoral candidate will be able to divide complex processes mechatronic systems in more simple process.

**theoretical teaching**

1. Banker's algorithm without feature process.
2. Banker's algorithm with the features of the process.
5. Processes with urgent priorities in the non-classical RR algorithm.

**practical teaching**

PhD student will become familiar with the work of RR algorithm and servicing process. Recognize different processes characteristic of Mechatronics systems and apportioned them according to features that will mapped in priorities. Nonclassical RR algorithms allow different treatment processes were characterized with priorities. Analyzing a number of Case studies Ph.D. candidate will identify processes of three classes: urgent, high-priority, and classical.

**prerequisite**

C or C++

**learning resources**

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

**number of hours**

lectures: 35
research: 0

**assessment of knowledge (maximum number of points - 100)**
feedback during course study: 5
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 45
project design: 0
final exam: 50
requirements to take the exam (number of points): 50

references
Optimal control of mechanical systems

**ID:** PhD-3491  
**teaching professor:** Obradović M. Aleksandar  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** oral

**goals**

To introduce students to the mathematical theory of optimal control and allow students to solve problems of optimal control of mechanical systems.

**learning outcomes**

Upon successful completion of this course, students will be able to formulate the problem of optimal control of mechanical systems with finite number of degrees of freedom and to resolve it, including numerical solution of systems whose movement is described by nonlinear differential equations of motion.

**theoretical teaching**


**practical teaching**

- 

**prerequisite**

None

**learning resources**


**number of hours**

lectures: 35  
research: 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: 50

project design: 0

final exam: 50

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

references


Optimization of aerospace structures

**ID:** PhD-3257  
**teaching professor:** Simonović M. Aleksandar  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written

**goals**

Study of theoretical backgrounds and applying of contemporary optimization methods related to aerospace structures. Development of creative abilities for R&D and specific engineering problems approach using appropriate advanced optimization methods.

**learning outcomes**

Vast and comprehensive field of optimization of aerospace structures problems is covered with contemporary methods. Advanced methods for optimization of aerospace structures included, enable solving of optimization and design problems for contemporary aerospace structures of various types and materials.

**theoretical teaching**

Comply with the subject of the research of the candidate's doctoral thesis

**practical teaching**

Contents of exercises follows the exposed material.

**prerequisite**

There is no necessary requirement for attendance of Optimization of aerospace structures.

**learning resources**

Simlab - computer laboratory

**number of hours**

lectures: 35  
research: 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: 70  
project design: 0  
final exam: 30  
requirements to take the exam (number of points): 0

**references**
X.-S Yang, NATURE INSPIRED METAHEURISTIC ALGORITHMS, Luniver Press, 2010
V.Vsiliev, Z.Gurdal, OPTIMAL DESIGN THEORY AND APPLICATIONS TO MATERIALS
AND STRUCTURES, Technomic, 1999
Selected Journal Articles
Optimization of Thermal Power Plants

ID: PhD-3434  
teaching professor: Petrović V. Milan  
level of studies: Ph.D. (doctoral) studies  
ECTS credits: 5  
final exam: written

goals

1. The achievement of research and expert competence in optimization in thermal power plants.
2. The achievement of high level of theoretical knowledge
3. The acquisition of research and expert knowledge to optimize thermodynamic cycle (steam turbines cycles, gas turbine cycles, combined cycles).
4. The achievement of the techniques of process modeling.
5. Mastering the methods of experimental work in thermal power engineering.

learning outcomes

1. Expert and research deep knowledge of optimization in thermal power engineering
2. The development of critical thinking about energy use, fuel efficiency and environmental preservation
3. The optimization the steam turbine and gas turbine power plants.
4. Ability to use computer technology for modeling and calculations

theoretical teaching

Energy generation technology mix. Thermodynamic cycles in thermal power engineering.  
Project: Complex example of electricity cost calculation with parameter optimization.

practical teaching

Project: Complex example of electricity cost calculation with parameter optimization.

prerequisite

PhD student - Thermal power engineering

learning resources

Literature. Computing devices

number of hours

341
lectures: 35
research: 0

assessment of knowledge (maximum number of points - 100)

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

references

Stojanovic, Themal Turbomachinery, Gradjevinska knjiga, Belgrade, 1967.
Organization and methods of scientific research and communication

**ID:** PhD-3192  
**teaching professor:** Nedeljković S. Miloš  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** seminar works

**goals**

Guiding and learning students into methodology and organization of scientific and research work. Learning the use of contemporary tools for gathering and analysis of information. Learning of research methods - analytic and experimental. Learning standards in communication in international scientific environment. Learning how to write scientific reports and papers. Learning how to present the achieved results.

**learning outcomes**

Applicable knowledge on how to organize scientific and research work. Application and use of contemporary tools for gathering and information analysis. Critical approach to research methods. Knowledge of standard communication methods in international scientific community and establishing of international information exchange. Knowledge on how to write scientific reports and papers and its application. Knowledge on how to present the gained results.

**theoretical teaching**

Methods of organization of scientific and research work - environment, information possibilities, resources needed, plan of investigation, background for investigation and adding up of contemporary novelties incorporating self investigations. The use of contemporary tools for gathering and information analysis - libraries, internet, information exchange by personal contacts. Research methods - analytic, experimental and synthetic. Standard methods of communication in international scientific community - text editors, programming languages, diagrams, results description. Writing of scientific papers and reports - organization, contents, language, conclusions. Presentation of results - equipment and programs for it, the way of slides preparation, oral communication.

**practical teaching**

Preparation of the exam in groups - computer search for relevant scientific information, writing of the research paper, computer and oral presentation of the work.

**prerequisite**

No special conditions

**learning resources**

**number of hours**

- lectures: 35  
- research: 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: 60
project design: 0
final exam: 30
requirements to take the exam (number of points): 70

references

Oscillations of mechanical systems

**ID:** PhD-3490  
**teaching professor:** Obradović M. Aleksandar  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** oral

**goals**

Introduce students to the basic concepts of linear and nonlinear oscillations and oscillations of elastic bodies.

**learning outcomes**

By gaining knowledge in this course, students will be able to effectively solve complex problems of linear and nonlinear oscillations and oscillations of elastic bodies.

**theoretical teaching**


**practical teaching**

-

**prerequisite**

None

**learning resources**

Vuković, J., Obradović, A., Linear vibrations theory of mechanical systems, Mašinski fakultet, Beograd, 2007.,

Butenin N. V., Elements of nonlinear vibrations theory, Faculty of Mechanical Engineering, Belgrade, 1985.

**number of hours**

345
lectures: 35
research: 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: 50
project design: 0
final exam: 50
requirements to take the exam (number of points): 50

**references**

Performance Analysis of Manufacturing Systems

ID: PhD-3011

**teaching professor:** Babić R. Bojan

**level of studies:** Ph.D. (doctoral) studies

**ECTS credits:** 5

**final exam:** seminar works

**goals**

This course introduces analytical approaches for modeling and analyzing manufacturing and production systems. Production systems, such as flow lines, are often operating in an uncertain environment, e.g., uncertain demand or random processing capacities. With respect to lean management principles, robust planning approaches need to consider such stochastic elements. In addition, the production process is often highly time-dependent, for example due to capacity ramp-ups, seasonal demand patterns, and decreasing machine reliability over time.

In order to support decisions for such uncertain and dynamic manufacturing systems we apply queuing theory. The basic concepts of this underlying theory are developed in sufficient detail. Several general concepts of robust planning are discussed. Additionally, analytical performance approximations are introduced and used to analyze economies of scale or the value of flexible capacities.

**learning outcomes**

Students learn to understand the impact of stochastic variations in production systems. After this course students are familiar with the theory and practice of capacity analysis of stochastic manufacturing systems. They learn to adapt and to apply analytical approximations and robust planning methods.

**theoretical teaching**

Components of manufacturing systems and their integration; Systems for material handling; Organization and management of FMS; FMS modeling techniques; The use of simulation in the design and management of FMS; The application of artificial intelligence techniques in the design and management of FMS; The concept of virtual factories.

**practical teaching**

Softwares for modelling and analysis of real systems based on discrete event simulation (lab work).

**prerequisite**

Defined by curriculum of study programme/module.

**learning resources**

1. B. Babic, Handouts, University of Belgrade, Faculty of Mechanical Engineering, 2011, 18.1
2. B. Babic, Electronic classroom for distance learning (http://147.91.26.15/moodle/), University of Belgrade, Faculty of Mechanical Engineering, 2011, 18.13
3. AnyLogic simulation software
number of hours

lectures: 35
research: 0

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

H. Tempelmeier, H. Kuhn (1993), FLEXIBLE MANUFACTURING SYSTEMS - DECISION SUPPORT FOR DESIGN AND OPERATION, John Willey & Sons.
Planning, Performing & Controlling Projects

**ID:** PhD-3334  
**teaching professor:** Babić R. Bojan  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** seminar works

**goals**

The purpose of the course is to present a systematic approach to the planning, performance, and control of projects. One goal of this course is to introduce students to techniques that will allow them to start, develop, and complete municipal, industrial or scientific projects more efficiently and effectively. General approach in this course has three parts: Describe the general requirements for planning, performing, and controlling projects; Explain how those requirements are applied through the use of examples; Learning through students' work on their own projects.

**learning outcomes**

Upon completing this course, students will be able to:
- Lead and manage people and resources.
- Applies concepts for communicating effectively with project teams, stakeholders, and sponsors.
- Demonstrates a strategic alignment between business needs and project outcomes.
- Assesses project risks.
- Can apply concepts for planning, executing, and controlling project activities to assure outcomes that meet stakeholder expectations.

**theoretical teaching**

- The Systematic Approach (Projects, Programs & People; Planning for Performance - Steps in Project, Concurrent Engineering; Phases of Project)
- The Conception Phase (Purpose, Goal and Activities)
- The Study Phase
- The Design Phase
- The Implementation Phase
- Project Management (Management Functions, Organizations, Styles; Project Staffing; Project Reporting; Project and Program Control, etc.)
- The Project Plan (Establishing of Responsibility for Tasks; Project Schedule; Costs and Budgets; Monitoring and Controlling a Project, etc.)
- Specifications and Reports (Preparing Specifications; Contracts and Change Notices; Trip and Meeting Reports; Periodic Project Reports, etc.)
- Modeling and System Design (The Need for Models, Human Factors Considerations, Modeling Applications, Model Interconnecting and Testing)

**practical teaching**

prerequisite

Defined by curriculum of study programme/module.

learning resources

(1) B. Babic, Z. Miljkovic, Handouts, University of Belgrade, Faculty of Mechanical Engineering, 2010
(2) B. Babic, Z. Miljkovic, Electronic classroom for distance learning (http://147.91.26.15/moodle/), University of Belgrade, Faculty of Mechanical Engineering, 2011,

number of hours

lectures: 35
research: 0

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

Harvey Maylor, Project Management, Financial Times Press, 2010
Carl Chatfield and Timothy Johnson, Microsoft Office Project 2003 Step by Step, Microsoft Press, 2004
Power transmission of locomotives - control and optimization

ID: PhD-3140  
teaching professor: Lučanin J. Vojkan  
level of studies: Ph.D. (doctoral) studies  
ECTS credits: 5  
final exam: written

goals

The aim of the course is to introduce students with specific problems in the power transmission in locomotives (motor-train) and allow them to acquire the necessary skills to work in this field.

learning outcomes

The aim of the course is to introduce students with specific problems in the power transmission in locomotives (motor-train) and allow them to acquire the necessary skills to work in this field.

theoretical teaching


practical teaching

Nothing

prerequisite

Finished course fundamentals of electrical engineering and construction in previous studies.

learning resources

Literature that is available in the Faculty Bookstore and Library; Handouts available on lectures; Internet resources (KOBSON).

number of hours

lectures: 35  
research: 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: 70
project design: 0
final exam: 30
requirements to take the exam (number of points): 0

references

Lj. Krsmanovic, A. Gajic, Turbomachines, Faculty of Mechanical Engineering, University of Belgrade, Belgrade, 2006.
Principles and Concepts of Industrial Air Pollution

ID: PhD-3223
**teaching professor:** Radić B. Dejan
level of studies: Ph.D. (doctoral) studies
ECTS credits: 5
final exam: seminar works

goals

Getting to know the candidates with problems and solving problems in the field of air pollution control with appropriate scientific methods; subject is made as an advanced course in the area of air protection at the doctoral studies.

learning outcomes

Upon completion of the course it is expected that the candidate has mastered the scientific knowledge pertaining to the analysis and evaluation of scientific papers, procedures and methods of analysis of sources of air pollution, laboratory work, as well as the advanced processes of modeling of the transport of solid and gaseous components in the atmosphere.

theoretical teaching


practical teaching

Students work under the supervision of teacher one seminar paper that needs student to apply knowledge.
If needed laboratory work and visits to industrial facilities.

prerequisite

-

learning resources

Laboratory and computational equipment.

number of hours

lectures: 35
research: 0

assessment of knowledge (maximum number of points - 100)
feedback during course study: 5
test/colloquium: 0
laboratory exercises: 15
calculation tasks: 0
seminar works: 50
project design: 0
final exam: 30
requirements to take the exam (number of points): 0

references

Scientific papers from Environmental Science and Technology, Chemosphere, Energy i sl.
Principles of modeling in process engineering

ID: PhD-3494
*teaching professor:* Genić B. Srbislav
*level of studies:* Ph.D. (doctoral) studies
*ECTS credits:* 5
*final exam:* written+oral

goals

Introduction to the mathematical and physical modeling as a basis for research and practical engineering work in process engineering

learning outcomes

Gaining knowledge of mathematical and physical modeling in process engineering

theoretical teaching

Modeling - definition, basic concepts
Mathematical model - a mathematical description of the objects
Mathematical analysis of the results of the experiment (measurements)
The mathematical description of the fluidodynamic structure

practical teaching

Examples of mathematical modeling in process industry

prerequisite

learning resources

number of hours

lectures: 35
research: 0

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 50
laboratory exercises: 0
calculation tasks: 10
seminar works: 0
project design: 0
final exam: 30
requirements to take the exam (number of points): 70

references
Product Development in Mechanical Engineering

**ID:** PhD-3517  
**teaching professor:** Miloš V. Marko  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written

**goals**

Mastering the scientific method in understanding the process of transformation of knowledge into the technical system, the development of methods for this transformation, the development of creative abilities in the preparation and application of knowledge and data. The study methodology development of new products, trends and tendencies of technical systems in the future.

**learning outcomes**

Студент докторских студија уведен у истраживање метода и процеса развоја нових производа тј. нових техничких система за будућност. Уведен нову област пропулзивног истраживања и развоја методологије за подстицање креативности у развоју нових техничких система.

**theoretical teaching**

Aspects of product development (technical, social, economic, ecological and aesthetic). Philosophy and vision in product development in mechanical engineering. Methodologies and tools in product development. Approaches to the development of products in engineering and in industrial design (integrated, simultaneous, multi-disciplinary, collaborative, axiomatic, empirical, robust, virtual, ....). Creativity in product development and design, innovation. Knowledge engineering, information systems and decision-making in product development and design. Calculations, simulations, experiments (modeling, development of models, 3D scanning and printing, virtual reality, testing of structures and parts). Restrictions and coercion in product development (user needs, technology needs, reliability and safety in operation, vibration, noise, ...- Design for reliability, Design for Vibration and Noise, Design for Cost, Design for Quality, Design for User,. ...). Harmonization of the needs, constraints, properties and the environment (living and working environment).

**practical teaching**

The research process, methods and application tools in the development of new products ie. new technical systems. Developing creativity-oriented development of new technical systems. Preparation and defense of the seminar paper.

**prerequisite**

-

**learning resources**

Laboratory for Engineering Design LECAD. Journals and proceedings from key conferences in this field. Software for modeling and product development. 3D printer and others.
number of hours

lectures: 35  
research: 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: 70  
project design: 0  
final exam: 30  
requirements to take the exam (number of points): 0

references
Production Planning and Control Systems

**ID:** PhD-3401
**teaching professor:** Puzović M. Radovan
**level of studies:** Ph.D. (doctoral) studies
**ECTS credits:** 5
**final exam:** written+oral

**goals**

Surveys the design, development, implementation and management of production planning systems, including master production scheduling, aggregate planning, material requirements planning, capacity and inventory planning and production activity control. Students will be exposed to contemporary approaches such as just-in-time, theory of constraints and the relationship of enterprise-level planning and control systems to the overall materials flow.

**learning outcomes**

Students should be able to articulate and apply the following tools and practices of production planning and control:

- The elements, processes, and technologies comprising the field of Manufacturing Planning and Control
- Enterprise Resource Planning (ERP)
- Material Requirement Planning system technologies
- Inventory flow and planning models – JIT, MRP, etc.
- Capacity planning
- Production Activity Control Techniques
- supply chain optimization, integration and transformation.

**theoretical teaching**

- The elements, processes, and technologies comprising the field of Manufacturing Planning and Control
- Enterprise Resource Planning (ERP)
- Material Requirement Planning system technologies
- Inventory flow and planning models – JIT, MRP, etc.
- Capacity planning
- Production Activity Control Techniques
- supply chain optimization, integration and transformation.

**practical teaching**

This course will enable to student learning by applying the techniques of Production Planning and Control through the project.

**prerequisite**

There are no prerequisites

**learning resources**

Handouts in e-form /In Serbian/. Instructions for laboratory exercises /In serbian/.
Instructions for project design /In Serbian/. One-student-one-computer scheme in a computer room. Software tool for application development (Oracle, MS Access, Progress, ...)

**number of hours**

lectures: 35  
research: 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: 0  
project design: 60  
final exam: 30  
requirements to take the exam (number of points): 50

**references**

Stephen N. Chapman: The Fundamentals of Production Planning and Control  
Jorg Thomas Dickersbach and Gerhard Keller: Production Planning and Control with SAP ERP (2nd Edition)  
Avraham Shtub: Enterprise Resource Planning (ERP): The Dynamics of Operations Management
**Propulsion of projectiles**

**ID:** PhD-3183  
**teaching professor:** Micković M. Dejan  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written

**goals**

The acquisition of contemporary knowledge in the field of interior ballistics and rocket propulsion.

**learning outcomes**

Students acquire advanced knowledge in the field of classical projectiles and missiles.

**theoretical teaching**

Two-phase interior ballistic models.  
Erosion of the gun barrel.  
Interior ballistic tests.  
Experimental research methods in interior ballistics.  
Modern rocket propellants.  
Modeling of rocket engine performances in non-stationary regimes.  
Optimization of propellant grain geometry.  
Structural analysis of the propellant grain.  
Subsystems of rocket engines with liquid propellants.

**practical teaching**

Two-phase interior ballistic models - calculation examples.  
Erosion of the gun barrel - selected models.  
Interior ballistic tests - preparation and measurements.  
Experimental research methods in interior ballistics - new methods.  
Modern rocket propellants - survey and analysis.  
Modeling of rocket engine performances in non-stationary regimes - calculation examples.  
Optimization of propellant grain geometry - selected examples.  
Structural analysis of the propellant grain - finite elements method.  
Subsystems of rocket engines with liquid propellants - practical solutions.

**prerequisite**

No.

**learning resources**

number of hours

lectures: 35
research: 0

assessment of knowledge (maximum number of points - 100)

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

references

Quality Engineering Techniques

ID: PhD-3559  
teaching professor: Stojadinović M. Slavenko  
level of studies: Ph.D. (doctoral) studies  
ECTS credits: 5  
final exam: seminar works

goals

Detailed study of quality engineering techniques and their application in models of quality management and other standardized management systems. Generating knowledge for practical application of quality engineering techniques in everyday engineering practice. Developing new and improving existing quality management models by applying different skills and models of quality engineering techniques.

learning outcomes

After completion of the teaching process, students will own the necessary knowledge for understanding, researching and resolving problems related to the implementation and improvement of good quality management practices and other standardized management systems. They will also be able and competent to engage in scientific research in this field.

theoretical teaching

Theoretical teaching embraces six units: 1. Advanced models of quality management; 2. Correlation between quality engineering techniques and quality management models. 3. The basic quality engineering techniques. 4. Manager quality engineering techniques. 5. Seven advanced quality engineering techniques. 6. Research problems in this area. Selected examples of application. Our research in this area.

practical teaching

Analysis of case studies of good practice application of quality engineering techniques. Analysis research problems in this area.

prerequisite

MSc degree, primarily technical faculty.

learning resources

1. Handouts for each lecture. 2. The instruction for making seminar work. 3. The monograph in the field of quality and production metrology (in preparation). 4. Facility and technical equipment: Laboratory for production metrology and TQM.

number of hours

lectures: 35  
research: 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: 60
project design: 0
final exam: 40
requirements to take the exam (number of points): 50

references

Quantitative Research Methods in Aviation

**ID:** PhD-3182  
**teaching professor:** Mitrović B. Časlav  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** project design

**goals**

This course will provide an in-depth study of quantitative research methods and associated uni-variate and bi-variate statistical techniques used to describe, explore, clean, analyze, and interpret numerical data. Emphasis will focus on integrating applied data analysis skills with conceptual understanding of methodological issues. Also, introducing students to methods and organization of scientific research. Introduces the students to the types of documents produced by scientists. The study of the structure of scientific documents. Mastering methods for planning and carrying out projects.

**learning outcomes**

Ability to contribute to scientific research.  
Student's ability to create and prepare scientific publications.  
Ability to organize and control scientific projects.  
Students will focus on scholarly application of quantitative methods to aviation-related topics and aviation data.

**theoretical teaching**

Topics will include: data management, variables, units of analysis, data scales, descriptive statistics (central tendency, variability), distributions, sampling theory, statistical assumptions, statistical inference, data integrity, outlier identification and handling, missing data handling, reliability, internal and external validity, measurement, measurement error, variable roles (predictor-outcome), study and experimental design, inductive-deductive scientific reasoning, causation, hypothesis testing, statistical significance, effect size, statistical power, statistical comparison of means, statistical tests of association, simple and multiple regression, data coding, graphic representation of data, and APA-style dissemination of findings.

**practical teaching**

After each topic students get homework which they submit to professor. At the end of lecture students present their the project. Quality of work and quality of presentation determine final exam mark.

**prerequisite**

No preconditions

**learning resources**

Computer laboratory, projector, laptop

**number of hours**
lectures: 35
research: 0

**assessment of knowledge (maximum number of points - 100)**

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

**references**
Queuing Systems - Theory and Applications

ID: PhD-3391
teaching professor: Bugarić S. Uglješa
level of studies: Ph.D. (doctoral) studies
ECTS credits: 5
final exam: written

goals

The purpose of this course is to present mathematical theory that has application to the problems of design and analysis of queuing systems. Although these systems are usually very complex, it is often possible to abstract from the system description a mathematical model whose analysis yields useful information. Focus is based on service systems viewed as stochastic processes, exploiting the theoretical framework of queuing theory. Includes multidisciplinary perspectives involving Engineering, Statistics, Psychology and Marketing.

learning outcomes

Course provides a rigorous treatment of basic models commonly used in modelling real servicing systems in areas such as: real life (banks, supermarkets, call centres, traffic, transport etc.), emergency centers (hospitals), material flow, maintenance, warehousing etc. Major outcome is to qualify researcher to use queuing models as a decision support and forecasting tools in order to ensure stability of service systems, operational quality of service etc. in a real world servicing systems.

theoretical teaching

Stochastics processes (nonhomogeneous Markov process & homogeneous Markov process (chain), Chapman–Kolmogorov equations forward and backward, irreducible process, ergodic process, limiting system state probabilities)
Birth-and-death processes (Pure birth process -Poisson process, Pure Death process - analytical solution in time, relations between arrival–service time and number of arrived–departure units).
Elementary queuing models (Single server system with finite storage, single server system without storage, single server system with infinite storage (system characteristics, transition rate matrix Q, state-transition-rate diagram, system of differential and linear equations, system characteristics)
Multi server queuing system with finite storage (Multi server system with finite storage–general model, system characteristics, transition rate matrix Q, state-transition-rate diagram, system of differential and linear equations, system characteristics)
Finite customer population queuing systems (Single server finite customer population systems, Multi server finite customer population systems (system characteristics, transition rate matrix Q, state-transition-rate diagram, system of differential and linear equations, system characteristics)
Bulk queues (Bulk arrival systems–arbitrary and constant group size, system characteristics, transition rate matrix Q, state-transition-rate diagram, system of differential equations, system of linear equations; Bulk service systems, system characteristics, transition rate matrix Q, state-transition-rate diagram, system of differential and linear equations, system characteristics).
The application of queueing theory (Decision making, relationship between average delay and service cost, definition of total costs, servicing costs and waiting costs, formulation of
waiting-cost functions, definition of objective function, decision models: model 1 – unknown c, model 2 – unknown μ and c, model 3 – unknown λ and c).

**practical teaching**

Solving of working examples (Methodology of modelling, solving and optimising real problems using queuing theory models)
Laboratory work i.e. use of existing software or writing adequate one.

**prerequisite**

Students should have (but not necessary) a background in probability, statistics, mathematics, computer science.

**learning resources**

5. Personal computers.

**number of hours**

lectures: 35
research: 0

**assessment of knowledge (maximum number of points - 100)**

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

**references**

Kleinrock, L, QueueingSystems-Volume 1 Theory, John Wiley & Sons, 1975.
Regimes and energy efficiency of thermal power plants

**ID:** PhD-3435  
**teaching professor:** Petrović V. Milan  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written

**goals**

1. The achievement of research and expert competence in off-design operation of thermal power plants.  
2. The achievement of high level of theoretical knowledge  
3. The acquisition of research and expert knowledge to calculate behavior of thermal power plants at off design conditions (steam turbines cycles, gas turbine cycles, combined cycles).  
4. The achievement of the techniques of process modeling.  
5. Mastering the methods of experimental work in thermal power engineering.

**learning outcomes**

1. Research and expert knowledge of the off-design operation of thermal power plants.  
2. Development of critical thinking about energy use  
3. Capability to calculate off-design operation and the most important indicators of the economy of thermal power plants.  
4. Ability to use computer technology and numerical methods for modeling and calculations

**theoretical teaching**

Off design operation of steam turbines. Off design operation of steam turbine stages.  

**practical teaching**

Numerical simulation of operation of steam turbines, gas turbines, turbocompressors and thermal power plants.

**prerequisite**

PhD student - Thermal power engineering

**learning resources**

Literature. Computing devices

**number of hours**

lectures: 35
research: 0

**assessment of knowledge (maximum number of points - 100)**

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

**references**

Stojanovic, Thermal Turbomachinery, Gradjevinska knjiga, Belgrade, 1967.
Rehabilitation Biomechanics

**ID:** PhD-3125  
**teaching professor:** Lazarević P. Mihailo  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** oral

**goals**

Introduce students to the problems of medical devices on the example of a number of modern devices that are in widespread use in rehabilitation purposes. Train students to critically approach the problem and define the most important biomedical and other parameters of given rehabilitation device which is projected as well as parameters of patient or to optimal implement existing biomedical device in rehabilitation.

**learning outcomes**

PhD student acquire the basics of designing and applications of medical devices, studying this subject. Theoretical considerations, a detailed analysis of modern devices of practical use and self-development project, to connect the previously acquired knowledge in mathematics, physics, mechanics, electrical engineering with electronics and automatic control, to implement the lessons learned in engineering practice.

**theoretical teaching**

The basic concepts of assistive medical devices, rehabilitation biomechanics; defining the specifications of assistive medical devices on the basis of biomedical measurement using statistical analysis. Introduction to the basics of the functioning of assistive medical devices and defining the basic problems of designing assistive medical devices, as following: a pacemaker, defibrillator, artificial lung, cochlear implants and other devices for the sense of hearing and vision, implants and dentures in dental implants in orthopedics, prosthetics and orthotics for the arms and legs, wheelchairs, exoskeleton, neuro-controlled devices

**practical teaching**

Elaboration of detailed numerical examples and the following examples in designing assistive medical devices: pacemakers, defibrillators, artificial lung, cochlear implants and other devices for the sense of hearing and sense of vision. There will also be considered examples of implants and dentures in dental implants in orthopedics, prosthetics and orthotics for the hands and feet, wheelchairs, exoskeleton, neuro-controlled devices. In consultation with their faculty stuff, tudent will be required to develop the concept of working the assistive medical device as well as to project/analysis proposed assistive medical device

**prerequisite**

none

**learning resources**

[2] Written abstracts from the lectures (Handouts)  
number of hours

lectures: 35
research: 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: 50
project design: 0
final exam: 50
requirements to take the exam (number of points): 30

references

R. Fries, Reliable Design of Medical Devices, CRC Press Taylor & Francis Group, Boca Raton, Florida, 2006
Yoseph Bar-Cohen, Biomimetics, Biologically Inspired Technologies, CRC Press Taylor & Francis Group, 2006
Reliability and dinamics of power transmission units

ID: PhD-3518
teaching professor: Rosić B. Božidar
level of studies: Ph.D. (doctoral) studies
ECTS credits: 5
final exam: seminar works

goals

Mastering of knowledge and research methods of elementary reliability of power transmission components and the overall reliability of the gear transmission units. Mastering the research methodology of vibration and noise generation mechanism in these systems. Mastering the methodology of defining the structural parameters of the gear components based on reliability, vibration and noise design constraints

learning outcomes

After successful completion of the course, PhD students should be able to:
- Use reliability and dynamics of the MS as the limits (constraints) in defining the design parameters at the robust level and at axiomatic principle.
- Define and use elementary Reliability for design of gear units components (gears, bearings, seals, joints, etc.), related to a certain potential damage.
- Decompose structure of the gear unit, decompose the overall reliability of the design to the level of components and then to integrate the structure and properties into the system.
- Identify dynamic disturbances in the gear unit structure, identify the process of disturbance transferring through structure and emission into the surrounding.
- Harmonize the design parameters of the gear unit in order to reduce the vibration and noise

theoretical teaching

An overview of the elementary reliability and application of this reliability as Design Constraint in design parameters definition. Elementary reliability of gears, bearings, couplings, seals, shafts, shaft joints and hubs, steering mechanism, etc. Correlation of reliability and probability of service conditions and the probability of failure of the gear unit components. Deduction of gear unit overall reliability to the level of components and defining of boundary levels. Disturbance processes in the gear units and vibrations and noise generation. Transmission of disturbance energy through the structure of the system. Principles of dynamic processes alignment with the limitations of the gear vibration and noise levels.

practical teaching

Research, examination of relevant references, experimental determination the probability of service and critical conditions of gear unit components elementary reliability. Vibration and noise testing of gear transmission unit components. Numerical analysis of dynamic parameters of gear unit components. Determination of design parameters. Preparation and defense of the seminar work.

prerequisite

Knowledge of linear algebra, numerical mathematics, basic statistics and basic machine elements and mechanics. Computer programming in Python/MATLAB.
learning resources

Laboratory for gears and gear transmission units, Laboratory for vibration and noise, Software for numerical analysis - FEM, Software for vibration and noise measurement and for processing of measurement results.

number of hours

lectures: 35
research: 0

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 10
seminar works: 55
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

Research and Development Methodology

**ID:** PhD-3558  
**teaching professor:** Grbović M. Aleksandar  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written

**goals**

The main goal of this course is to provide PhD students with grounding in good Research & Development Methodology practice, inculcate good habits of research for the future and show how the process of understanding and improving development can become more effective and efficient. The second goal is to present generic and systematic research methodologies intended to improve the quality of research – its academic credibility, industrial significance and societal contribution. The practical part of the course is reinforced by many R&D project examples and placed in the context of the proposed methodology to demonstrate the application of the variety of approaches available.

**learning outcomes**

Students will become familiar with useful and well-ordered methods within a common research ethos, as well as a methodological frameworks for research projects and programmes. By the end of the course students should also have enough skills to start writing their own scientific papers, as well as PhD theses.

**theoretical teaching**

1. Main Issues in Research and Development  
1.1 Lack of Overview of Existing Research  
1.2 Lack of Use of Results in Practice  
1.3 Lack of Scientific Rigour  
1.4 Need for a Methodology  
2. Research and Development Methodology  
2.1 Introduction  
2.2 Methodological Framework  
2.3 Types of Research Within the RD Framework  
2.4 Representing Existing and Desired Situations  
2.5 Success Criteria and Measurable Success Criteria  
3. The Main Stages of R&D  
3.1 Research Clarification  
3.2 Descriptive Study  
3.3 Prescriptive Study  
3.4 Comparison with Other Methodologies  
4. Research Clarification  
4.1 Research Clarification Process  
4.2 Identifying Overall Topic of Interest  
4.3 Clarifying Current Understanding and Expectations  
4.4 Selecting Type of Research  
4.5 Determining Areas of Relevance and Contribution  
4.6 Formulating Overall Research Plan  
4.7 General Guidelines on Doing Research
practical teaching

Example Research Projects
P.1 Overview of the Examples
P.2 A Process-based Approach to Computer-supported Engineering Design
P.2.1 Introduction and Aim of Research
P.2.2 Research Approach
P.2.3 Results
P.2.4 Evaluation of the Results
P.2.5 Conclusions About the Research Approach
P.2.6 Continuation
P.2.7 References
P.3 Teamwork in Engineering Design
P.3.1 Introduction and Aim of Research
P.3.2 Research Approach
P.3.3 Results
P.3.4 Evaluation of Results
P.3.5 Conclusions About the Research Approach
P.3.6 Continuation
P.4.7 References

prerequisite

No previous experience or skills are required.

learning resources

Handouts, Virtual classroom (Moodle), Power Point presentations, Recommended literature and websites.
number of hours

lectures: 35
research: 0

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 25
laboratory exercises: 0
calculation tasks: 0
seminar works: 0
project design: 30
final exam: 40
requirements to take the exam (number of points): 50

references

A. Grbovic: Handouts, Faculty of Mechanical Engineering, Belgrade 2010.
Lucienne T.M. Blessing • Amaresh Chakrabarti, DRM, a Design Research Methodology,
Springer 2009.
Risk Management

**ID:** PhD-3260

**teaching professor:** Spasojević-Brkić K. Vesna

**level of studies:** Ph.D. (doctoral) studies

**ECTS credits:** 5

**final exam:** written

**goals**

Training for self-use of risk management tools and for self-development of new models, integration of available and improvement of existing models for risk assessment.

**learning outcomes**

By completing the program of this course student acquires following scientific and research abilities:

1. Risk management diagnosis in the company,
2. Application of risk management tools,
3. Improvement of existing risk assessment models
4. Designing new models for risk assessment and
5. Writing scientific papers in the field of this course.

**theoretical teaching**


**practical teaching**

Case studies in the areas of theory in form of seminal work with possible paper publication.

**prerequisite**

Enrolled semester.

**learning resources**

2. ESPRIT Course material - "Enhancing Industrial Safety, Environmental Protection and Risk Management in Serbia by means of dedicated Training, Education and Technology Transfer", 2009.
4. Scientific papers from Scopus, Science Direct and other databases.

**number of hours**
lectures: 35
research: 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: 50
project design: 0
final exam: 50
requirements to take the exam (number of points): 20

**references**


ESPRIT Course material - "Enhancing Industrial Safety, Environmental Protection and Risk Management in Serbia by means of dedicated Training, Education and Technology Transfer", 2009.


Scientific papers from Scopus, Science Direct and other databases.
Selected chapters of biomechanics of tissue and organs

**ID:** PhD-3478  
**teaching professor:** Lazarević P. Mihailo  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** oral

**goals**

To introduce students to the application of fundamental principles and laws of biomechanics of tissues and organs in order to understand and study them. Establishment of appropriate biomechanical model of tissue and organs using modern theory of continuum biomechanics, the possibility of simulations based on them in order to confirm the experimental data, the possibility of applying for the purposes of design and design basis of the same. It allows the potential cooperation with experts in medicine or work in specialized clinical institutions.

**learning outcomes**

Attending the course students acquire the ability to analyze the possibility of solving the current problems related to the analysis of biomechanical properties and characterization of human tissues and organs with the use of scientific methods and procedures as well as computer technology and equipment. In addition, students can connect advanced knowledge of mechanics (rheology), continuum biomechanics, mathematics, fractional calculus, physics, physiology with application in the bioengineering of tissues and organs.

**theoretical teaching**

Introduction to biorheology. Fundamentals of continuum biomechanics. Basic definitions and properties of fractional derivatives and integrals-fractional calculus. Basic assumptions of theory of elasticity (LTE), (hyperelasticity) including theory of nonlinear elasticity. (Non)linear dynamic behavior of tissues/ organs - appropriate biomechanical models. Fundamentals of the theory of viscoelasticity (TV)/viscoplasticity (TP). Elements of poroelasticity. Modeling of biological tissues / organs using TV / TV with special emphasis to TV: stress relaxation, creep, hysteresis of considered biomechanical system. In particular, the use of Maxwell, Kelvin-Voigt and Zener model of integer and fractional order are suggested as well as studied of their properties.  

**practical teaching**

Introductory examples of tensor analysis/ continuum biomechanics. Fundamental conservation laws are introduced and illustrate using examples from animate as well as inanimate systems. Modelling using TE, THE biomechanical properties of connective tissue (ligaments, tendons), muscles. Examples of Maxwell, Kelvin-Voigt and Zener biomechanical model of integer order in the time/ frequency domain. Examples Maxwell, Kelvin-Voigt and Zener biomechanical model of fractional order in the time/ frequency domain. An example of modeling viscoelasticity of artery applying Zener model: fractional and integer order. Practical problem-solving using numerical methods will be introduced. Modeling the behavior of biological tissue using TVE / TVV: the case of lung tissue, skin. Viscoplastic
model Hildebrandt. The case of the dynamic behavior of the diaphragm. Examples of organs / tissues injury: head and spinal cord-biomechanical models of the same. Tolerance of organs / tissues to impact load. The growth of tissues and organs - such as bones. Examples of artificial models of tissues / organs (body parts).

prerequisite

none

learning resources

7. Written abstracts from the lectures (Handouts)

number of hours

lectures: 35
research: 0

assessment of knowledge (maximum number of points - 100)

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

references

Selected chapters of mechanics

ID: PhD-3170
teaching professor: Mitrović S. Zoran
level of studies: Ph.D. (doctoral) studies
ECTS credits: 5
final exam: oral

goals

The goal of this course is that students learn the basic elements: analytical mechanics, dynamics of rigid bodies system, stability of mechanical systems, oscillation of mechanical systems, optimal control theory.

learning outcomes

By gaining knowledge in this course, students will be able to carry out research in the fields of mechanical engineering, where there are problems of mechanics of rigid bodies. Students will be able to solve the basic problems of analytical mechanics, dynamics of rigid bodies system, stability of mechanical systems ...

theoretical teaching

General principles of mechanics. Lagrange principle. Dalamber-Lagrange principle

practical teaching

/

prerequisite

Defined by the curriculum study of PhD studies program.

learning resources

Vuković J., Selected chapters of mechanics, Handouts, Faculty of mechanical engineering, Belgrade 2006.

number of hours

lectures: 35
research: 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: 50
project design: 0
final exam: 50
requirements to take the exam (number of points): 30

references

Selected chapters of mechanics of robots

**ID:** PhD-3119  
**teaching professor:** Lazarević P. Mihailo  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** oral

**goals**

Introduce students to basic concepts of kinematics and dynamics of robotic systems. It is possible to solve direct and inverse kinematics and dynamics of the robot system (RS) using modern theory based on Rodriguez transformation matrix, quaternions as well as the theory of finite rotations. Determination (simulation) models of RS - i.e. differential equations of motion of the RS, which are important in practical problems of the RS. Practical simulations RS using MATLAB, Cyberbotics Webots software package and students work with laboratory robot NEUROARM.

**learning outcomes**

By attending this course student acquires the ability to analyze problems and synthesis solutions to the problem of kinematics and dynamics of robotic systems using scientific methods and procedures as well as computer technology and equipment. This enabled him applying solutions to practical problems of robotic systems as well as monitoring and implementation of innovation in the development of new robotic systems.

**theoretical teaching**


**practical teaching**

Examples of determining the number of degrees of motion of the RS; Calculation the transformation matrix (MT)- in case of Euler angles, and Hamilton-Rodriguez parameters-quaternions. Determination of kinematic characteristics of the robot segment (RSE): angular velocity and angular acceleration RSE, velocity and acceleration of the observed point-RSE cases of Rezales and Euler angles. Application of Rodriguez transformation matrix, determine position vectors which define the configuration of the RS-in MATLAB environment. Kinematic characteristics of the i-th robot segment. Solving the direct and inverse kinematic task of RS. Determination of (planar) inertia tensor RSE, RS. Obtaining momentum and angular momentum, kinetic energy, the coefficient of the metric
tensor RS, generalized forces, Christoffel symbols of the first kind. Solving the direct and inverse dynamics task of the RS. Examples of DIFE of RS simulation in MATLAB-GUI, MATHEMATICA environment, an example of a redundant RS. An example of simulation RS using Cyberbotics Webots package. Example of control of the RS-laboratory robot NeuroArm with 7 degrees of freedom in the MATLAB environment.

prerequisite

none

learning resources

1. Čović M. V. Lazarević, Mechanics of Robot, MF Belgrade, 2009. (Book)
2. Lazarević M. Exercises in mechanics of robot, MF Belgrade, 2006. (ZZD)
5. Written abstracts from the lectures (Handouts)
6. Cyberbotics Webots - software package
8. MATLAB, MATHEMATICA - mathematics software packages

number of hours

lectures: 35
research: 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: 50
project design: 0
final exam: 50
requirements to take the exam (number of points): 30

references

Selected topics from propulsion

ID: PhD-3295  
teaching professor: Fotev G. Vasko  
level of studies: Ph.D. (doctoral) studies  
ECTS credits: 5  
final exam: seminar works

goals

Introduction of students with real overall engine, and engine energetic elements, real performances.

learning outcomes

Student who is capable to deal with performances of real propulsor, or some of its energetic elements, like:

intake  
compressor – fan  
main Combustor – reheat combustor  
turbine  
nozzle.

theoretical teaching

Education starts with introduction into the calculation methods for real engine performances. After that it follows the student, chosen chapters (owe all propulsor or its main energetic elements).

practical teaching

Performances of real propulsor.  
Performances of real intake.  
Performances of real compressor - fan.  
Performances of real primary combustor and afterburner.  
Performances of real turbine.  
Performances of real nozzle.

prerequisite

Msc. aerospace.

learning resources

CFD FLUENT, Payton.

number of hours

lectures: 35  
research: 0

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0

386
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 70
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

Selected Topics in Aerodynamics

**ID:** PhD-3454  
**teaching professor:** Bengin Č. Aleksandar  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written

**goals**

Introducing students to selected topics of theoretical and experimental aerodynamic in hypersonic, subsonic, transonic, supersonic and hypersonic speed area.

**learning outcomes**

Students will be introduced to the procedure of abstract thinking and creative idea generation, the methodology of the design and development of new aircraft and spacecraft on the most advanced technological solutions.

**theoretical teaching**

The characteristics in the subsonic, transonic, supersonic and hipersonic wind tunnel testing. Calculation methods in aerodynamics, Selected topics from the boundary layer theory and turbulent flow. The characteristics of flow at low Reynolds numbers.

**practical teaching**

Modeling and Simulation of flow with MATLAB, FLUENT etc. Simulation aerodynamic parameters in wind tunnels.

**prerequisite**

No special conditions.

**learning resources**


**number of hours**

lectures: 35  
research: 0

**assessment of knowledge (maximum number of points - 100)**
feedback during course study: 15
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 45
project design: 0
final exam: 40
requirements to take the exam (number of points): 40

references
Selected topics in aeroelasticity

ID: PhD-3053
teaching professor: Dinulović R. Mirko
level of studies: Ph.D. (doctoral) studies
ECTS credits: 5
final exam: project design

goals

1. Introducing students to the problems and modern methods of calculation and analysis of complex aeroelastic events, and their application in solving practical problems.
2. Introduce students to the methods of experimental investigation of dynamics of aircraft structures.
3. Introducing students to the phenomenon of fluid structure interaction.

learning outcomes

In the end of successfully completed course Students should be able to:

1. Define aeroelastic phenomena that might occur on the flying structures depending on the flight envelope for which the structure is designed.
2. Set the equations for torsion divergence lifting surfaces, reverse commands and flutter.
3. Solve aeroelastic equations in order to obtain the critical divergence Speed, control reversal speed and the critical speed of flutter.

theoretical teaching

1. Overview of Aeroelastic phenomena in mechanical, civil and aerospace engineering
2. Static aeroelastic phenomena
3. Dynamic aeroelastic phenomena
4. Section method, torsional divergence of lifting surfaces
5. Flutter, flutter types
6. Numerical methods for static aeroelasticity problems
7. Numerical methods for dynamic aeroelasticity problems
8. Application of La Place transformations in solving aeroelasticity problems

practical teaching

1. Prctical modeling of real lifting surfaces
2. Strucure response analysis, analysis of aeroelastict occurences (torsional divergence and flutter)

prerequisite

Numerical methods, Theory of elasticity, Structural Analysis

learning resources

Laboratory for Theory of elasticity and Aeroelasticity

number of hours
lectures: 35
research: 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: 50
final exam: 50
requirements to take the exam (number of points): 0

**references**

Principles of Aeroelasticity, Raymond Bisplinghoff, Holt Ashley, Dover Press
Aeroelasticity of Plates and Shells, E. H. Dowell
Studies in Nonlinear Aeroelasticity, Earl H. Dowell, Marat Ilgamov
Theoretical and Computational Aeroelasticity, William P Rodden
Selected topics in aircraft composite structures

**ID:** PhD-3445  
**teaching professor:** Dinulović R. Mirko  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** project design

**goals**

Mastering advanced structural analysis methods applied to flying vehicles composite structures.

**learning outcomes**

In the end of completed course students should be able to:

1. master theoretical knowledge in stress strain analysis of composite structures used in aerospace.  
2. apply presented methods in solving real problems related to composite aerospace structures and composite structures in general.

**theoretical teaching**

Elastic behaviour of multidirectional laminates  
symmetric laminates, balanced laminates  
Quasi-isotropic laminates  
Temperature effectes on laminate stress strain, analysis methods  
Laminate Failure analysis  
Types of laminate failure  
Strength analaysis  
FPF theory  
experimantal methods in laminate characterization

**practical teaching**

Stress strain analysis of complex composite structures using finite elements approach.

**prerequisite**

Structural analayis, composite structures

**learning resources**

laboratory for Theory of elasticity and aeroelasticity

**number of hours**

lectures: 35  
research: 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: 50
final exam: 50
requirements to take the exam (number of points): 0

references

Advanced Mechanics of Composite Materials and Structural Elements, Third Edition by V.V. Vasiliev
**Selected Topics in Bionics**

**ID:** PhD-3444  
**teaching professor:** Bengin Č. Aleksandar  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written

**goals**

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

**learning outcomes**

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

**theoretical teaching**


**practical teaching**

spintronic. Magnetic materials. DNA nano-products.

prerequisite

No special requirements

learning resources

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

number of hours

lectures: 35
research: 0

assessment of knowledge (maximum number of points - 100)

feedback during course study: 15
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 45
project design: 0
final exam: 40
requirements to take the exam (number of points): 40

references
Selected topics in fluid structure interaction

ID: PhD-3256

**teaching professor:** Simonović M. Aleksandar

**level of studies:** Ph.D. (doctoral) studies

**ECTS credits:** 5

**final exam:** written

**goals**

Study of theoretical backgrounds and applying of contemporary research methods related to fluid-structure interaction. Development of creative abilities for R&D and specific engineering problems approach using advanced fluid-structures analysis methods.

**learning outcomes**

Vast and comprehensive field of fluid-structural interaction is covered with contemporary approach methods. Advanced methods of fluid-structure interaction analysis included, enable extended analysis and solving of different types of problems in this field.

**theoretical teaching**

Comply with the subject of the research of the candidate's doctoral thesis

**practical teaching**

Contents of exercises follows the exposed material.

**prerequisite**

There is no necessary requirement for attendance of Selected topics in fluid structure interaction.

**learning resources**

Simlab - computer laboratory

**number of hours**

lectures: 35
research: 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: 70
project design: 0
final exam: 30
requirements to take the exam (number of points): 0

**references**
G. Galdi, R. Rannacher, FUNDAMENTAL TRENDS IN FLUID STRUCTURE INTERACTION, World Scientific, 2010
M. Paidoussis, S. Price, E. de Langre, FLUID STRUCTURE INTERACTIONS-CROSS-FLOW-INDUCED INSTABILITIES, Cambridge, 2010
Selected topics in material handling, constructions and logistics

**ID:** PhD-3021  
**teaching professor:** Bošnjak M. Srđan  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** seminar works

**goals**

Basic course goal: mastering practical skills which are necessary for solving the specific problems in fields of Material handling, Construction and Logistics (MHCL)

**learning outcomes**

Mastering the curriculum student gains: 1) general skills which can be used in in fields of MHCL (analysis, synthesis and anticipation of solution and consequences; development of critical approach) 2) specific skills (use of gained knowledge on solving the problems in fields of MHCL)

**theoretical teaching**

Selected topics in MHCL according to the candidate's preferences.

**practical teaching**

Selected topics in MHCL according to the candidate's preferences.

**prerequisite**


**learning resources**

1. Computers, Laboratory 516  
2. Software Matlab, Catia

**number of hours**

lectures: 35  
research: 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: 70  
project design: 0  
final exam: 30  
requirements to take the exam (number of points): 0
references

Selected according to the candidate's preferences
Selected Topics in Operations Research

**ID:** PhD-3023  
**teaching professor:** Bugarić S. Uglješa  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written

**goals**

An operations researcher faced with a new problem is expected to determine which techniques are most appropriate given the nature of the system, the goals for improvement, and constraints on time and computing power. For this and other reasons, the human element of OR is vital. Therefore, course goal is overwhelm with advanced scientific methods and techniques for obtaining alternative solutions of real world problems on which basis optimal analysis and synthesis of obtained solutions can perform in order to make decisions and predict consequences.

**learning outcomes**

Like any other tools, OR techniques cannot solve problems by themselves. So, outcome is to qualify researcher to solve concrete problems with application of specific advanced scientific methods, procedures and techniques using analysis, synthesis and prediction of solutions and consequences as well as to apply gained knowledge and skills in practice.

**theoretical teaching**

Topics for advanced research can be chosen (but not necessary) from following areas: Applied Probability and Statistics, Simulation, Stochastic Processes, Queuing Theory, Game Theory, Graph Theory, Inventory Planning, Decision analysis and Forecasting, Mathematical Programming, Mathematical Modelling of Operational Systems, Project management, and other areas connected with candidate research.

**practical teaching**

Practical part of the course is restricted to laboratory work i.e. use of existing software or writing adequate one.

**prerequisite**

Students should have (but not necessary) a background in statistics, system engineering, mathematics, computer science.

**learning resources**

4. Software: QSopt Version 1.0 (Linear programming problems).  
7. Personal computers.

**number of hours**

lectures: 35  
research: 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: 70  
final exam: 30

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

**references**

Selected topics in projectile design

**ID:** PhD-3544  
**teaching professor:** Elek M. Predrag  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written

**goals**

The aim of this course is to deepen the knowledge acquired from various fields related to the design of projectiles and warheads. Various phenomena related to the design of high explosive, penetrating and special warheads are treated.

**learning outcomes**

Student gets knowledge for design warheads, taking into account the modern knowledge regarding the mechanisms of their action. Student acquires a basis for scientific research in this field.

**theoretical teaching**

Warheads. 
Characteristics of targets. 
Special topics in high-explosive and anti-armor projectiles. 
Special chapters in special purposes projectiles. 
Fuzes.

**practical teaching**

Numerical modeling of warhead action mechanisms.

**prerequisite**

No.

**learning resources**


**number of hours**

lectures: 35  
research: 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: 50
project design: 0
final exam: 50
requirements to take the exam (number of points): 30

references
Selected topics in Wind Turbines

ID: PhD-3503
**teaching professor:** Simonović M. Aleksandar
**level of studies:** Ph.D. (doctoral) studies
**ECTS credits:** 5
**final exam:** oral

**goals**

The course covers in depth examination of topics selected by the instructor from among topics not covered in previous wind turbine design courses. The student will be introduced to advanced wind turbine design and control topics. The goal of this course is to expand student knowledge about wind turbine design, and to explore current-day ideas and innovations in this field, also advances in wind turbine component design such as rotors, blades, drivetrain and generators are covered.

**learning outcomes**

Students will enrich and deepen their knowledge of contemporary issues in the field of design, development and operation of wind turbines.

**theoretical teaching**

Advanced optimization of wind turbine blades
Aerodynamics and design of Vertical Axis Wind Turbines
Smart blade concept - possibilities of smart materials usage in wind turbine design and control.
Reliability and cost of energy of advanced wind turbine concepts

**practical teaching**

Practical course follows the lecture content. During the course the student develops computer models and simulations to verify the advanced concepts of wind turbine systems.

**prerequisite**

There is no necessary requirement for attendance of Selected topics in Wind Turbines.

**learning resources**

Simlab - computer laboratory

**number of hours**

lectures: 35
research: 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: 70
project design: 0
final exam: 30
requirements to take the exam (number of points): 0

references

Pesic S., Wind energy - Aerodynamics wind energy system with a horizontal axis rotor, Faculty of Mechanical Engineering, 1994., (in serbian)
Selected research articles and conference papers
Additional materials (written performed with the lectures, setting tasks, guidelines for solving the task).
Selected topics of logistics

**ID:** PhD-3206  
**teaching professor:** Petrović B. Dušan  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written

**goals**

Achieving and improving competency and academic skills in the process of advance industrial system design. Special emphasis is focused on development and improvement of creative skills and overwhelm with specific practical skills needed for professional practice using selected post operational research methods, procedures of analysis and synthesis for obtaining final goal which is optimal practical solution.

**learning outcomes**

Post graduate curriculum overcome enables converge of the following skills: analysis, synthesis and prediction of solutions in design process of complex solution of design of logistic systems in industry based on knowledge applying in practice using professional ethics as well as development of crucial and self-critical thinking and approach.

**theoretical teaching**

Selected logistic system in industrial environment (role of logistic system in industry, functions which system must achieved and its benefit for industry). Elements of logistic system (production based on end user demand, distribution and warehouse systems). Selected basic sub-systems of logistic system (production with defined capacity, transport with defined technology and distribution warehouse system). Place and role of the warehouse in logistic system. Application and effects of application of logistic systems in industry (territory coverage with defining location of production and end user, reduction of transport and storage costs and increase of flexibility towards end user). Previous analysis needed for system design (general conditions for urban planning, logistic and transport connections, energetic and human potential). Design process procedure.

**practical teaching**

Audit design lessons (Design of selected processes for logistic system – defining elements of selected logistic system and basic sub-systems for chosen logistic system. Introduction in warehouse design of palletized goods – defining of: reception area, main warehouse, distribution – order picking, shipping and warehouse management system). Project workmanship (Determining of the optimal location of the selected logistic system in macro surrounding – positioning of warehouse regarding to production and end user as a function of transport system. Project of warehouse for palletized goods - defining of: packing and capacity, work technology, layout, reception and shipping and warehouse management system).

**prerequisite**

There is no special conditions needed for course attending

**learning resources**
6. Practical instruction in industrial environment.
7. Personal computers.

**number of hours**

lectures: 35
research: 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: 30
final exam: 70
requirements to take the exam (number of points): 0

**references**

Selected topics of Strength of Constructions

**ID:** PhD-3510  
**teaching professor:** Milovančević Đ. Milorad  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** seminar works

**goals**

The aim of this course is to introduce students to some complex aspects of Strength of Constructions: sresses and strains in beams, combined loads, statically determinate and indeterminate problems, elastic and plastic deformations of beams; cylindrical shells exposed to combined loads, boundary conditions; model preparing for FEM calculations.

**learning outcomes**

1. Within the course students will learn various methods for analysis of: loads, supports, materials and geometry, statically determinate and indeterminate problems, as well as cylindrical shells.
2. Students will learn how to analyse stresses and determine failure of beams and cylindrical shells.
3. By completing this course students will become familiar with basic concepts of analyzing of different types of beams and cylindrical shells. A special attention will be devoted to the practical procedures of stress analysis of mechanical components, with numerical implementation of the most frequently used techniques.

**theoretical teaching**

1. Beams and curved beams.
2. Statically determinate and indeterminate problems.
3. Stresses and strains in beams.
5. Elastic and plastic deformations.
6. Cylindrical shells exposed to combined loads.
7. Boundary conditions.
8. Model preparing for FEM calculations.

**practical teaching**

1. Analytical examples.
3. Numerical examples of determination of the ultimate strength using diverse failure criteria. Practical applications of failure theory to the ultimate strength calculations of mechanical components.
4. Examples of numerical implementations of diverse modeling techniques

**prerequisite**

Taken exams:  
Strength of materials  
The base of strength of constructions
learning resources

The whole course material is well covered by hand-outs written by the lecturer of the course. Every attendee of the course will be provided his/hers own copy of the hand-outs. Apart of this, all the below mentioned books can be borrowed from the lecturers during the course or ordered on some relevant websites.

number of hours

lectures: 35
research: 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: 70
project design: 0
final exam: 30
requirements to take the exam (number of points): 1

references

Tuma and Munshi:"Advanced Structural Analysis", McGRAW-HILL book co.
Selected Topics of Terminal Ballistics

ID: PhD-3068
teaching professor: Elek M. Predrag
level of studies: Ph.D. (doctoral) studies
ECTS credits: 5
final exam: written

goals

The aim of the course is to provide students with contemporary advanced knowledge in the field of terminal ballistics. The focus of the study are two key areas of terminal ballistics: penetration mechanics and blast effect. The main goal is to successfully use the methods of analytical modeling and numerical simulation of these phenomena.

learning outcomes

Having successfully completed the course students should be able to:
- apply modern analytical methods for modeling of penetration/perforation processes,
- use the advanced numerical predictive techniques for modeling of different classes of penetration processes,
- calculate all relevant parameters of blast effect of a warhead,
- use numerical methods for modeling of blast effect.

theoretical teaching

1. Penetration mechanics
2. Blast

practical teaching

1. Penetration mechanics
2. Blast

prerequisite
learning resources


number of hours

lectures: 35
research: 0

assessment of knowledge (maximum number of points - 100)

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

references

Selected topics in structural analysis of flying vehicles

**ID:** PhD-3054  
**teaching professor:** Dinulović R. Mirko  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** project design

**goals**

Mastering advanced structural analysis methods in metallic and composite structures for flying vehicles.

**learning outcomes**

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

1. Have theoretical knowledge of structural analysis applied to aerospace structures.  
2. Apply theoretical knowledge learned, in solving practical problems.  
3. Understand the structural aircraft scheme.  
4. Be to effectively apply modern methods for the design and analysis of aircraft structures.

**theoretical teaching**

1. Introduction  
2. Tensor calculus  
3. Force method  
5. Aircraft as single elastic structure  
6. Displacement method  
7. Direct stiffness method  
8. Nonlinearity in structural analysis

**practical teaching**

1. Real aircraft structures modeling an stress-strain field analysis  
2. Metal and composite aircraft structure geometrical non linearity modelling

**prerequisite**

Structural analysis, Composite structures, Stuctural analysis of flying vehicles

**learning resources**

Laboratory for Theory of elasticity and Aeroelasticity.

**number of hours**

lectures: 35  
research: 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: 50
final exam: 50
requirements to take the exam (number of points): 50

references

Concepts and applications of finite element analysis, 3rd edition, Cook, Markus, Plesha
Advanced Structural Analysis, D. Menon
Advanced Methods of Structural Analysis, Igor A. Karnovsky, Olga Lebed
Selected Topics in Aircraft Armament Systems

**ID:** PhD-3504  
**teaching professor:** Simonović M. Aleksandar  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written

**goals**

The study of this course is to ensure adoption of advanced procedures and methods for problem solving related to aircraft armament. The course aim is to enable students for analysis and calculations of fire, rocket, bomber, mine and torpedo aircraft armament elements in order to obtain the best possible performance of airborne platforms and maximal action efficiency at specific application conditions of each of these types of armament. Analysis and calculation of these elements of aircraft weapons will precede the study of gunpowder and explosives as its integral parts. Students will also through course get better knowledge to the principles and functioning of the guidance and control of aircraft ordnance. Specially will be taken to the historical development of aircraft armament, and trends in the development of modern aircraft armament.

**learning outcomes**

Student will obtain, through these programs, following advanced subject - specific skills:

- fundamental knowledge and understanding of gunpowder and explosives  
- fundamental knowledge and understanding of different types of armaments and their application  
- fundamental knowledge and understanding of guidance and control of aircraft ordnance  
- calculation and analysis of aircraft weapons characteristics and their integration on aircraft through modern scientific methods and procedures

This course provides basic knowledge connectivity of mathematics, programming, mechanics, aerodynamics, flight dynamics and structures structural mechanics and their application to the design and calculation of aircraft armament and its integration.

**theoretical teaching**

Introduction to the field of aircraft armament and its historical development  
Division and classification of aircraft armament  
Development trends of aircraft armament  
Introduction to the field of gunpowder and explosives and its historical development  
Division and classification of gunpowder and explosives  
Research of gunpowder and explosives characteristics  
Aircraft firearm armament  
Aircraft missile armament  
Aircraft bomber armament  
Guidance and control

**practical teaching**

Division and classification of aircraft armament with practical examples
Division and classification of gunpowder and explosives with practical examples
Calculations of gunpowder and explosives
Division and classification of aircraft firearm armament with practical examples
Calculations and analysis of aircraft firearm armament
Division and classification of aircraft missile armament with practical examples
Calculations and analysis of aircraft missile armament
Division and classification of aircraft bomber armament with practical examples
Calculations and analysis aircraft bomber armament
Analysis of guidance and control system and methods with practical examples

prerequisite

There is no necessary requirement for attendance of Selected Topics in Aircraft Armament Systems.

learning resources

Simlab - computer laboratory

number of hours

lectures: 35
research: 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: 70
project design: 0
final exam: 30
requirements to take the exam (number of points): 0

references

Jankovic S. Aerodinamika projektila, Faculty of Mechanical Engineering, Belgrade, 1979,КДА (in Serbian)
Additional materials (written performed with the lectures, setting tasks, guidelines for solving the task).
Selected research articles and conference papers
Selected Topics in Computational aerodynamics

**ID:** PhD-3505  
**teaching professor:** Simonović M. Aleksandar  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written

**goals**

The course is linked to the subject taught in the course Computational aerodynamics at previous study levels, but the material is conceived so that the object can be conceivable to the students who have not listened the course Computational aerodynamics. After a brief review of the basic theoretical equations governing the flow and analytical way of solving the problems of fluid dynamics, students are introduced to the basic and advanced methods of Computational aerodynamics. The course deals with the basics of panel methods, finite difference and finite volume methods. Through solving practical problems, student learns basic and advanced techniques of mesh generation, application of boundary and initial conditions and methods of calculation and visualization of results.

**learning outcomes**

Upon course completion, students gain practical and theoretical knowledge that will serve as a basis for further research and practical work in the field. By solving problems carefully selected by the teacher, the student will gain the necessary experience and will become able to independently determine the complexity of the problem, way of solving and predict potential problems that may arise in the development of the model, mesh generation and other steps in problem solving and to address these problems with adequate approaches. During the course, students will master the techniques of computer programming necessary to solve the problems of fluid dynamics as well as the technique of using existing software for the simulation in this area.

**theoretical teaching**

Brief introduction and derivation of the transport equation for fluid flow.  
Presentation of selected problems solved by analytic methods.  
Fundamentals of panel methods, finite difference and finite volume methods.  
Basic and advanced techniques of mesh generation.  
Demonstration of possible approaches to solution of viscous fluid flow.  
The influence of compressibility and simulation of compressible fluid flow.  
Simulation of turbulent flow.

**practical teaching**

Contents of exercises follows the exposed material. Students master the techniques of programming and use of existing software solutions in the area of computational aerodynamics. The examples and problems were selected so that the students are introduced to the problems that arise in the practical applications and trained in use of appropriate solving techniques.

**prerequisite**

There is no necessary requirement for attendance of Selected Topics in Computational aerodynamics.
aerodynamics.

**learning resources**

Simlab - computer laboratory

**number of hours**

lectures: 35
research: 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: 70
project design: 0
final exam: 30
requirements to take the exam (number of points): 0

**references**

Petrovic Z, Stupar S, CFD one, Faculty of Mechanical Engineering, 1992
Selected research articles and conference papers.
Additional materials (lecture hand-writings, problem settings, task solving guidelines)
Ship Dynamics

**ID:** PhD-3418  
**teaching professor:** Bačkalov A. Igor  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** seminar works

**goals**

The goal is to comprehend the contemporary calculation methods for ship seakeeping and ship maneuvering.

**learning outcomes**

A student should become capable of investigating various phenomena related to seakeeping, stability in waves and maneuvering in waves.

**theoretical teaching**

The course on Ship Dynamics is consisted of two parts: Ship seakeeping and Ship maneuvering. Within the seakeeping part, the following problems are analyzed: methods for calculation of added mass and damping, coupled equations of ship motion in oblique waves, nonlinear roll, parametric roll, etc. Maneuvering part of the course deals with the slender ship theory application and nonlinear maneuvering theory.

**practical teaching**


**prerequisite**

Completed M.Sc. course in Naval Architecture.

**learning resources**


**number of hours**

lectures: 35  
research: 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: 40  
project design: 0  
final exam: 50
requirements to take the exam (number of points): 0

references

**Ship Waves**

**ID:** PhD-3419  
**teaching professor:** Bačkalov A. Igor  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written

**goals**

Learning basic theory and practical procedures for calculation of ship wave resistance.

**learning outcomes**

A student should be capable of performing calculation of ship wave resistance using the available theoretical background.

**theoretical teaching**

Ship wave resistance is one of the most important and, in the same time, most complex problems of ship hydrodynamics. Some simplified methods of wave resistance calculation are laid out in the Master course on Ship Resistance, however, due to complexity of the subject, without going too much into details. In the course on Ship Waves these problems are thoroughly analyzed. The linear theory is examined and the relation between wave amplitude and ship resistance is given. Ship waves in both deep and shallow water are examined and appropriate formulas are derived (Michell's and Sretensky's integrals). The introduction to the nonlinear theory of ship waves as well as the case of the arbitrary ship hull shape are given.

**practical teaching**

Calculation of ship wave resistance using Michell’s and Sretensky’s integrals.

**prerequisite**

Completed M.Sc. course in Naval Architecture.

**learning resources**

Scientific papers, available model test data and commercial programming languages.

**number of hours**

lectures: 35  
research: 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: 40  
project design: 0  
final exam: 50  
requirements to take the exam (number of points): 0

references

M. Hofman и D. Radojičić "Resistance and propulsion of high speed craft in shallow water", Faculty of Mechanical Engineering, Belgrade 1996
Software Tools for Project Management

ID: PhD-3347
teaching professor: Babić R. Bojan
level of studies: Ph.D. (doctoral) studies
ECTS credits: 5
final exam: seminar works

goals

Project Management deals with seeking new methods of planning, organizing, and controlling non-routine tasks. The management of a project differs in several ways from management of a typical enterprise. The goal of a project team is to accomplish its prescribed mission and then disband; though this is easier said than done. Project Management has been around for some time, though it has recently become more important because of the shifting emphasis on teams in accomplishing tasks. Modern methods of defining, planning and managing large projects. Computer software and network modeling are used to support the efficient scheduling of interdependent activities.

learning outcomes

By successfully completing this course, students will be able to:
1. Understand the concepts of project planning and organization, budgeting and control, and project life cycles.
2. Understand concepts related to organizational workflow including the staffing process, project planning elements, and the project plan contents and project communications.
3. Master several basic project scheduling techniques and resource constrained scheduling.
4. Understand the related concepts of organizational forms, conflict resolution, and issues related to leadership and task management in a project environment.
5. To use software tools for project management.

theoretical teaching

Managing Projects With Software Tools (Creating A New Project Plan, Defining Project Properties)
Creating a Task List (Entering Tasks, Defining the Right Tasks for the Right Deliverable, Estimating Durations, Entering a Milestone, Organizing Tasks into Phases, Top-Down and Bottom-Up Planning, Linking Tasks, Documenting Tasks, Checking the Plan's Duration)
Assigning Resources to Tasks (Assigning Resources to Tasks, Assigning Additional Resources to a Task, Assigning Material Resources to Tasks)
Formatting and Printing Your Plan (Creating a Custom Gantt Chart View, Drawing on a Gantt Chart, Formatting Text in a View, Formatting and Printing Reports)
Tracking Progress on Tasks (Saving a Project Baseline, Tracking a Project as Scheduled, Entering a Task's Completion Percentage, Entering Actual Values for Tasks)
Managing A Complex Project

practical teaching

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Demonstration of project control and reporting techniques by using appropriate project management software. The following phases should be covered: Project initiation phase – Creation of initiation report, Making of conception report, Feasibility report forming.

**prerequisite**

Defined by curriculum of study programme/module.

**learning resources**

Appropriate software packages will be needed to demonstrate project control and reporting techniques. Packages might include time and cost scheduling packages, documentation and procurement control packages, spreadsheet packages, graphic presentation packages.

B. Babic, Electronic classroom for distance learning (http://147.91.26.15/moodle/), University of Belgrade, Faculty of Mechanical Engineering, 2011,

**number of hours**

lectures: 35  
research: 0  

**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**

Harvey Maylor, Project Management, Financial Times Press, 2010  
Carl Chatfield and Timothy Johnson, Microsoft Office Project 2003 Step by Step, Microsoft Press, 2004
Special Algorithms of Mechatronic

ID: PhD-3016  
teaching professor: Bengin Č. Aleksandar  
level of studies: Ph.D. (doctoral) studies  
ECTS credits: 5  
final exam: project design  
goals  
The aim of the course is that the student be able to independently define and solve practical optimization problems for mechatronic systems.

learning outcomes  
Mastering the course, the student acquires knowledge of the entire optimization process in mechatronic problems.

theoretical teaching  
Optimization problems in mechatronic. Trajectory optimization, motion control, vibration reduction. Mathematical model of the mechatronic systems, the objective function and the constraints. Optimization problem defining. Selection of an appropriate numerical solution technique. Applying solution technique using existing software packages. Verification and validation of the obtained results (e.g. obtained accuracy, required calculation time).

practical teaching  
Workshops with basic examples.

prerequisite  
Basic knowledge of the mechatronics and optimization techniques.

learning resources  
MATLAB software.

number of hours  
lectures: 35  
research: 0  

assessment of knowledge (maximum number of points - 100)  
feedback during course study: 0  
test/colloquium: 20  
laboratory exercises: 20  
calculation tasks: 0  
seminar works: 0  
project design: 30  
final exam: 30  
requirements to take the exam (number of points): 30
references
Special Chapters from the Flight Dynamics of The Aircraft

**ID:** PhD-3449  
**teaching professor:** Mitrović B. Časlav  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written

**goals**

Introducing students to the dynamics of atmospheric flight, orbital and interplanetary flight. Also, during this course in subjects like complex phenomena and dynamic stability and control of modern aircraft.

**learning outcomes**

The ability to deal with scientific research. Student’s ability to create and prepare scientific publications. Ability to organize and monitor research projects. Students will be introduced to the procedure of abstract thinking and creative idea generation, the methodology of the design and development of new aircraft and spacecraft on the most advanced technological solutions.

**theoretical teaching**

- Equations of aircraft motion in the atmospheric, orbital and interplanetary flight.  
- Modelling of aircraft flight dynamics.  
- Dynamic stability, maneuverability, agility and maneuverability of aircraft.  
- Differential equations of aircraft stability.  
- The criteria of stability of dynamical systems.  
- The characteristic functions of dynamical systems.  
- Aerodynamic stability derivatives of aircraft.  
- Systems of equations of generalized stability and control of aircraft and missile systems.  
- Fundamentals of air-space-nautics.  
- Basis of dynamics of the cosmic missiles.  
- The orbits of satellites.  
- Disorders of satellite orbits.

**practical teaching**

Laboratory exercises accompany the theoretical classes.  
Are based on a number of projects.  
Each project was initiated at a lecture on the topic of each project.

**prerequisite**

No special conditions

**learning resources**

Laboratory for Aerotechnics  
Wind tunnel  
Computer lab
number of hours

lectures: 35
research: 0

assessment of knowledge (maximum number of points - 100)

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

references

M. Nenadović, Fundamentals of Cosmic Flight, Belgrade: Institute of Technical Sciences of SANU and University of Belgrade, 1979
Ashish Tewari, Atmospheric and Space Flight Dynamics: Modeling and Simulation with MATLAB and Simulink, Birkhauser, 2006
Special Topics in Applied Aerodynamics

**ID:** PhD-3447  
**teaching professor:** Kostić A. Ivan  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written

**goals**

The primary aim of the course is focusing the students on complex subjects in applied aerodynamics, with an overview of necessary background knowledge in theoretical and computational aerodynamics. The contents on which the course is focused changes every academic year, depending on problems that students intend to investigate within their PhD dissertations, with the aim to improve the future scientific research in the area selected for the thesis.

**learning outcomes**

After accomplishing this course, student must be able to understand, explain and apply different aspects of complex problems in theoretical, computational and primarily applied aerodynamics, in the sense of solving operational engineering problems. Important outcome is also the acquiring of specific knowledge in the areas planned for investigation within the student’s thesis preparation process.

**theoretical teaching**

The contents of the course change every year depending on the students requirements, so only some of the most often considered and analyzed topics will be stated: characteristics and calculation of airflow around slender bodies; non-standard air vehicle design schemes and concepts; aerodynamic interference (wing-fuselage-tail surfaces, etc.); aerodynamics of road and railroad vehicles; ground influence on aerodynamic characteristics of air vehicles and ground vehicles; atmospheric boundary layer and aerodynamics of buildings; aerodynamic characteristics in unsteady air flow conditions; aerodynamic characteristics in stall condition, etc.

**practical teaching**

None.

**prerequisite**

None.

**learning resources**

Lectures in electronic form, flow simulation examples via the demo movies and clips, and graphical simulations available through the virtual workshop (program MOODLE), internet resources. Vlaero CFD software. Ansys FLUENT 14.

**number of hours**

lectures: 35
research: 0

**assessment of knowledge (maximum number of points - 100)**

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

**references**

I. Kostić, Z. Stefanović: Special Topics in Applied Aerodynamics - handouts, University of Belgrade, Faculty of Mechanical Engineeering, Belgrade, 2014.

Different NASA и AIAA technical reports and papers, etc.
Special Topics in Computational Aerodynamics

**ID:** PhD-3540  
**teaching professor:** Svorcan M. Jelena  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** oral

**goals**

Detailed acquaintance and implementation of numerical methods adequate for solving a specific engineering problem in aerodynamics closely related to the student's research topic. Throughout the course various software packages or programming languages can be used.

**learning outcomes**

Recognition of the most influential causes of the flow/behavior that is being modeled. Adequate choice and rational understanding of the employed numerical methods as well as boundary conditions definition.  
Individual work in the form of numerical computation of the unknown physical quantity (quantities) and post-processing.  
Work in different research areas - applied mathematics, programming, computational aerodynamics, optimization, etc. and their coupling.

**theoretical teaching**

In accordance with the selected research topic.

**practical teaching**

In accordance with the selected research topic.

**prerequisite**

There are no mandatory conditions/prerequisites for course attendance.

**learning resources**

Classroom, projector, computer (laptop), computational software tools.

**number of hours**

lectures: 35  
research: 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: 70  
final exam: 30
requirements to take the exam (number of points): 30

references

Stability of Motion of a System

ID: PhD-3171  
**teaching professor:** Mitrović S. Zoran  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** oral

**goals**

Training students to independently research in the field of stability of motion of holonomic and nonholonomic mechanical systems, particularly in the case of the stability of the equilibrium position of the stationary motion of mechanical systems, as models of real technical objects.

**learning outcomes**

After this course, students will be able to independently solve problems of stability of mechanical systems.

**theoretical teaching**


**practical teaching**

/

**prerequisite**

Defined by the curriculum study of Phd studies program.

**learning resources**


**number of hours**

lectures: 35  
research: 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: 50
project design: 0
final exam: 50
requirements to take the exam (number of points): 30

references

Statistical process control

ID: PhD-3470
teaching professor: Babić R. Bojan
level of studies: Ph.D. (doctoral) studies
ECTS credits: 5
final exam: written

goals

Learning methods for Statistical process Control.

learning outcomes

Student will be capable to undertake capability analysis, including analysis of non-normal data, and understand the meaning of the indices Cp/Cpk and Pp/Ppk. They will be able to implement statistical process control methods in production and construct and interpret control charts for variables and attributes. They will be capable to demonstrate understanding of the important relationship between capability analysis and process stability as observed on control charts.

theoretical teaching

The objectives and benefits of SPC – assessing process performance, distinguishing special from common causes, introduction to statistics underlying SPC, variation in manufacturing processes and its causes; calculation of basic statistics including standard deviation; the normal and standard normal distribution and use of the normal tables to calculate tail values; sampling distribution of the mean; process capability analysis; conducting process capability studies – identifying characteristics, specifications, and/or tolerances; distinguishing between natural process limits and specification limits, and calculating process performance metrics including percent defective and PPM; calculating process capability indices Cp, Cpk, capability ratio, and assessing process capability; calculating process performance indices Pp and Ppk and assessing process performance; identifying and selecting characteristics for monitoring by control chart; rational sub-grouping; construction and interpretation of the spc charts. Distinguishing between common and special causes using the rules for determining statistical control; Interpreting the charts using the rules for determining statistical control.

practical teaching

Training using EXCEL software in solving above explained tasks.

prerequisite

Defined by the curriculum of studies.

learning resources

1. MS Office-EXCEL
2. Book prepared for teaching above explained tasks /In English/

number of hours
lectures: 35
research: 0

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

Steam Turbines - Advanced course

**ID:** PhD-3389  
**teaching professor:** Petrović V. Milan  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written  

**goals**

1. The achievement of research and expert competence in the field of steam turbines.  
2. The achievement of high level of theoretical knowledge  
3. The acquisition of research and expert knowledge in steam turbines.  
4. The achievement of the techniques of process modeling.  
5. Mastering the methods of experimental work in thermal power engineering.  

**learning outcomes**

1. Expert and research deep knowledge of steam turbines.  
2. The development of critical thinking about energy use, fuel efficiency and environmental preservation  
3. The ability of calculate steam turbines.  
4. Ability to use computer technology for modeling and calculations  

**theoretical teaching**

Project: Steam Turbine Power plant: Calculation of the heat balance diagram and energy and exergy analysis.  

**practical teaching**

Project: Steam Turbine Power plant: Calculation of the heat balance diagram and energy and exergy analysis.  

**prerequisite**

PhD Student - Thermal power engineering.  

**learning resources**


**number of hours**

lectures: 35  
research: 0  

**assessment of knowledge (maximum number of points - 100)**

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

references

Stojanovic, Themal Turbomachinery, Gradjevinska knjiga, Belgrade, 1967.
A. Leizerovich: Steam Turbines for Modern Fossil-Fuel Power Plants
Lakshninarajana, B: Fluid Dynamics and Heat Transfer of Turbomachinery, Wiley, 1996,
Stochastic Dynamics

**ID:** PhD-3432  
**teaching professor:** Trišović R. Nataša  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written

**goals**

Introduction to the fundamental concepts of the random variables, random processes and stochastic differential equations. Introduction to the analysis of the mechanical systems subjected to random excitation. Understanding and application of the software tools used in the process of analysis.

**learning outcomes**

Students gain knowledge about the theory of random vibration of mechanical systems and about software tools needed to the analysis.

**theoretical teaching**

Sigma algebra, probability function, probability space, random variables, distribution function, probability density function and normal distribution, random process, stationarity and ergodicity, auto correlation, white noise, Brownian motion and Wiener process, stochastic differential equations (SDE), Ito’s integral, Fokker-Planck equation, linear SDE, Euler method, Monte Carlo Simulation, linear structures with single degree of freedom, system response to random excitation, nonstationary excitation, means and covariance, linear structures with multi degrees of freedom, response to atmospheric turbulence, linear continuous structures, response to boundary layer turbulence, nonlinear structures, nonlinear stress, structural failure resulting from dynamic response, types of structural failure, envelope distribution, fatigue failures.

**practical teaching**

MatLab, generating random variables, functions rand, randn, generating random process white noise and Wiener, computation of Ito’s integrals, solving SDE, computation distribution function, computation of the probability density function (PDF), evolution of PDF, Euler method, simulation of mechanical systems, simulation of mechanical systems using Euler method, computation of the probability density function of the response of the mechanical systems, computation of the probability of failure, simulation of the probability of fatigue failure.

**prerequisite**

Without conditions

**learning resources**
Written lectures (handouts)

MATLAB software


Gilat, A., MATLAB: An Introduction with Applications, John Wiley & Sons, 2005

**number of hours**

lectures: 35
research: 0

**assessment of knowledge (maximum number of points - 100)**

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

**references**


A. Cvetkovic, S. Radojevic, MATLAB I, Faculty of Mechanical Engineering, Belgrade, 2012.
Stress and strain measurement

ID: PhD-3161

teaching professor: Milovančević Đ. Milorad

level of studies: Ph.D. (doctoral) studies

ECTS credits: 5

final exam: seminar works

goals

The main aim is to master the experimental methods for measuring stress and strain construction. Introducing the achievements and possibilities of modern methods of measurement. Accent is given to the processing ekstenziometrijskih and optical methods with modern electronics and optics.

learning outcomes

Methods can be applied to models and real structures. Experimental methods of analysis allows for obtaining data relevant to the analysis of the structure and to assess its strength and stability.

theoretical teaching

Basic concepts of development and the importance of experimental methods to the study design. A brief review of existing methods of measurement. Strain gauge measurement methods. Optical methods of measurement. Interferometric and holographic methods. Methods brittle varnish. Inductive, capacitive and magnetic measurement methods.

practical teaching

The practical application of the experimental method of measuring stress and strain on the structural model in the laboratory.

prerequisite

No conditions.

learning resources

1. Handouts from the website of Department.
2. V.Brcic, R.Cukic, Experimental methods in the design of structures, building books, Belgrade (1988)

number of hours

lectures: 35
research: 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: 40
project design: 0
final exam: 50
requirements to take the exam (number of points): 40

references
Structural Analysis of Material Handling Machines

**ID:** PhD-3431  
**teaching professor:** Gašić M. Vlada  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** seminar works

**goals**

The goals of the course are derived so that students can:
  1) get to know the basics in the postulations of the theory of elasticity
  2) get to know the theory of plates
  3) understand the problems in dynamics of structures
  4) get practical skills for performing analysis in structural dynamics

**learning outcomes**

The successful completion of the course means that student got:
  1) skills which can apply in practice (analysis, synthesis, formulation of the equivalent model; development of the critical approach);
  2) specific skill (usage of the gained theoretical knowledge in solving the practical problem in the field of dynamics of structures of material handling machines)
  3) scientific work in the field of moving load dynamics

**theoretical teaching**


**practical teaching**

Formulation of the dynamic models of the different crane structures and their identification. Modal analysis at finite element models of the crane structures and bucket wheel excavator structure. Postulation of the forced vibration, implementation in model and analysis of the structural responses. Consultations for seminal work.

**prerequisite**

Courses: Theory of Mechanical Vibrations, Steel Structures

**learning resources**

1. Computer laboratory  
2. Suitable softwares for Mathematics, Programming and FEA

**number of hours**

lectures: 35  
research: 0

**assessment of knowledge (maximum number of points - 100)**
feedback during course study: 0

seminar works: 30

final exam: 70

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

references

Petković, Z.: Metalne konstrukcije u Mašinogradnji 2, Beograd, 2005
Structural Integrity and Life

ID: PhD-3221
teaching professor: Radaković J. Zoran
level of studies: Ph.D. (doctoral) studies
ECTS credits: 5
final exam: seminar works

goals

The course topics are presented through theoretical and practical lectures (i.e. class exercises - worked calculation examples, laboratory exercises, written seminars - presentations, consultations, etc.) that introduce candidates to the field of applied fracture mechanics to structural integrity and component life assessment for specific structures (e.g. pressure vessels, pipelines, parts and equipment in power and processing industries, loaded structures in various fields of modern transport engineering - aircraft, land-based and floating vehicles, etc.). Assessment of the behaviour of damaged material and structural parts is understood, with the application of modern methods for predicting the operating capacity of a damaged structure and knowledge of experimental techniques for determining critical fracture mechanics parameters and the remaining operational life assessment.

learning outcomes

Upon the successful completion of the course, the students are able to:
• Identify the key factors and mechanisms leading to structural damages and failures
• Identify the behaviour of the damaged material in structures
• Understand structural state monitoring
• Implement advanced technical concepts of fracture mechanics through analysis and structural integrity and life assessment
• Formulate the stress intensity factors of fatigue cracks
• Calculate the fatigue crack growth in conditions of specific loading type
• Investigate and determine critical fracture mechanics parameters by applied experimental techniques
• Select and apply different techniques to mitigate and control damage evolution of structures in-service

theoretical teaching

Theoretical course: Introduction (historical review; design approach; material characteristics and fracture; dimensional analysis). Basic concepts (linear elastic fracture mechanics; effects of stress concentration of the flaws in the material; Griffith equilibrium energy; energy release rate; instability and the R-curve; stress analysis of cracks; correlation between K and G; crack tip plasticity; fracture in the state of plane strain; mixed mode fracture; elastic-plastic fracture mechanics; COD; J integral; dynamic and time dependent fracture; crack growth in conditions of creep; visco-elastic fracture mechanics). Material behaviour (fracture mechanisms in metals; ductile fracture; cleavage; ductile-brittle transition; intercrystalline fracture). Applications (fracture toughness testing; K-R curves; testing the J integral; CTOD; testing the fracture of welded joints).

practical teaching

mechanisms in metals. Ductile fracture. Cleavage. Ductile to brittle fracture transition.
CTOD. Testing the fracture of welded joints. Laboratory exercises. Consultations.

prerequisite

Numerical Methods, Basics in Welding, FEA

learning resources

1. A. Sedmak, Application of Fracture Mechanics to Structural Integrity, (in Serbian),
   University of Belgrade, Faculty of Mechanical Engineering, 2003. (Monograph)
2. Written course material (theoretical and exercises - scripts/handouts).
3. Guidelines for preparing laboratory reports.
4. Internet resources.

number of hours

lectures: 35
research: 0

assessment of knowledge (maximum number of points - 100)

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

references

Structure testing methods

**ID:** PhD-3516  
**teaching professor:** Marinković B. Aleksandar  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written+oral

**goals**

Involve the students in research methodology by application of experimental methods. Introduce PhD students with the types, application procedure and with data processing of laboratory and exploitation testing of machine systems structures. To trained them in preparation and caring out of experiments and in using of experimental data.

**learning outcomes**

After successful completion of this course, the PhD student is qualified to perform experiments in the context of research projects and working on own dissertation aimed to be qualified for:

1. Measurement of physical quantities in solid structures (deformation, stress, loading, ...);
2. Planning and performing of experiments on mechanical systems in operation;
3. Laboratory testing of components of mechanical systems to the failure;
4. Laboratory testings of operating effects of mechanical systems (vibration, noise, reliability,...);
5. The statistical processing of test results and display of test results.

**theoretical teaching**

Introduction: The role of experimental results in comparing with analytical and numerical ones. Method of physical values measurement in solid structures (deformation, stress, load ...). Methods of machine systems testing in service conditions (preparation, organization and carrying out of experiments). Laboratory testing methods without machine parts failures. Testing methods to the failure (fatigue testing of models and real machine components – examples and characteristics). Statistical processing of fatigue testing results. Testing of machine components reliability. Vibration and noise testing of machine systems components. Frequency analysis of vibration and noise measured results. Diagnosis of conditions in machine systems.

**practical teaching**


**prerequisite**

no specific conditions

**learning resources**

Laboratory for gears and gear transmission units. Laboratory for vibration and noise of machine systems components.
number of hours

lectures: 35
research: 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: 70
project design: 0
final exam: 30
requirements to take the exam (number of points): 0

references

Jeff Wu C.F., Homada M.: EXPERIMENTS: Planing, Analysis and Parameters Design
Optimisation, - Wiley, New York 2000.;
D.Josifović: Experimental investigation of machine constructions 1, Mechanical Engineering
Faculty University of Kragujevac, 2000.
Substitution of Manual Tasks in Food Industry

ID: PhD-3151  
teaching professor: Miladinović D. Ljubomir  
level of studies: Ph.D. (doctoral) studies  
ECTS credits: 5  
final exam: project design

goals

In order to increase productivity, reduce production costs in various industries, as well as the development of different fields of science dealing with rehabilitation and support of disabled persons, it is necessary to simulate or replace human labor or movement with mechanical or mechatronic systems. The complexity of these systems is very large and the degree of integration of various scientific and engineering fields is high. The integration of different types of knowledge, technology and techniques requires exceptional creativity, analytical and research skills.

learning outcomes

After completing these classes Students should be capable to integrate, in an inventive way, existing knowledge and technology, the knowledge and technologies that will emerge in the future, in systems for the substitution of human labor and simulation of human movement. One of the most important outcomes is the adoption of the way of thinking and logic in the synthesis of such systems

theoretical teaching


practical teaching

Not provided.

prerequisite

No conditions.

learning resources

number of hours

lectures: 35
research: 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: 20
project design: 40
final exam: 30
requirements to take the exam (number of points): 40

references
Surface Engineering

**ID:** PhD-3031  
**teaching professor:** Vencl A. Aleksandar  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** oral

**goals**

The student attending this course should:
- Get familiar with the characteristics of surfaces exposed to friction and wear, as well as to get familiar with the possible interactions of surfaces with lubricant in the lubrication conditions;
- Understand the impact of individual characteristics on the size of the friction and wear at the macro, micro and nano level;
- Learn the basic principles of the most common techniques of surface modification and coating deposition processes.

**learning outcomes**

On the basis of mastered knowledge the student is qualified to:
- Analyze fundamental aspects of friction and wear;
- Analyze the surface texture and roughness parameters, including statistical methods and experimental measurements;
- Conducts analysis and synthesis of problems that occur in the mechanics of contact surfaces;
- Solves specific tribological problems (primarily to reduce friction and wear) using some of the surface modification methods and/or some of the coating deposition techniques;
- Applies methods for the temperature calculation of surfaces in contact and relative movement, including consideration of the running-in process and thermal effects;
- Recognize the main parameters that influence the tribological properties of a system at the nano level (nanotribology).

**theoretical teaching**

Study of the nature and characteristics of metallic and non-metallic materials surfaces, from the standpoint of values influencing the friction and wear. Analysis of the surface texture and roughness parameters, including statistical methods and experimental measurements. Geometrical and real area of contact. Mechanics of contact area, i.e. the stress distribution under load (Hertz contact). The runn-in process and thermal effects, i.e. calculation of the surface temperature. Mechanical and chemical interaction of surfaces exposed to friction and wear. Antiwear coatings and methods of surface modification. A separate chapter deals with the study of friction, wear and lubrication at the nano scale, i.e. nanotribology.

**practical teaching**

Preparing of the seminar paper.

**prerequisite**

No special requirements.
learning resources


number of hours

lectures: 35
research: 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: 70
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

Synthesis of mechanisms

ID: PhD-3533
teaching professor: Popkonstantinović D. Branislav
level of studies: Ph.D. (doctoral) studies
ECTS credits: 5
final exam: written

goals

Mastering the necessary knowledge in the field of Synthesis mechanisms. Recognition with the methods of synthesizing mechanisms and their application according to the appropriate technological requirement that mechanism, the machine should perform.

learning outcomes

By mastering the study program, the following subject-specific abilities are acquired: understanding the problems from Theory of Mechanisms and Machines; solving concrete problems using scientific methods and using adequate software.

theoretical teaching


practical teaching

Preparation for independent research of written literature, professional journals and websites in the field of application of synthesis mechanisms. Preparation of seminar work and project for concrete examples of synthesis of mechanisms using the SolidWorks software package.

prerequisite

There are no special conditions for attending this course.

learning resources

Pantelić, T., Ćulafić, G., Mehanizmi (Sinteza mehanizama), MF Beograd, 1986. Software: - MATLAB -SolidWorks

number of hours

lectures: 35
research: 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: 70
project design: 0
final exam: 30
requirements to take the exam (number of points): 0

references

Systems of artificial neural networks

**ID:** PhD-3168  
**teaching professor:** Miljković Đ. Zoran  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** seminar works

**goals**

Artificial neural networks (ANNs) present one of the most important and widely used paradigms of artificial intelligence. Thus, this subject aims to enable PhD students for independent development, modelling and application of artificial neural networks in domain of complexity of intelligent machine systems through theoretical and practical aspects of learning algorithms and neural networks training.

**learning outcomes**

The learning outcome of this subject considers the suitability for modelling and predicting changes of functional characteristics of systems and processes besides the introduction of PhD students into the basic methodology of complex problems modelling in mechanical engineering by the use of artificial neural networks which are able to learn and generalize the nature of phenomena on the basis of known experimental data. They can be trained in such way to find the solution, recognize the behaviour models with adequate accuracy, classify data and predict future events.

**theoretical teaching**

Theoretical education is organized into several parts:  
- Intelligent formalized methodologies; computational intelligence techniques - Adaptive processing and role of artificial neural networks (ANNs) in development of computational intelligence techniques, the history of development of ANNs;  
- ANNs-basic concepts - Structure of ANNs, processing element-neuron, activation function, learning algorithms of ANNs, simulation and processing of neural networks;  
- Models of ANNs - basic paradigms and examples;  
- Homogeneous ANNs - Perceptron, Back-propagation (BP) neural network, ART neural networks, Self-organizing map (SOM), etc.;  
- Heterogeneous ANNs (membrane potential, neural model, neural controller).

**practical teaching**

Practical education is organized into several parts:  
- ANNs in intelligent technologies - formalized conceptual design, group technology, feature recognition and part representation, advanced process planning, scheduling, recognition systems - image processing and analysis, monitoring and diagnostic of manufacturing processes, intelligent control of robots and machine systems, application in business and finances;  
- Developed software and their application - BPnet, ART-Simulator, MATLAB, Neuro Solutions, etc.

**prerequisite**

MSc degree of technically oriented faculty.
learning resources

[1] Z. Miljković, D. Aleksendrić, ARTIFICIAL NEURAL NETWORKS – solved examples with theoretical background (2nd ed.), Textbook, University of Belgrade, Faculty of Mechanical Engineering, 2018, 18.1 (In Serbian)/
[3] Software packages (BPnet, ART-Simulator, MATLAB), Laboratory CeNT, University of Belgrade, Faculty of Mechanical Engineering, 18.13
[4] Laboratory mobile robot prototype (Khepera II mobile robot with gripper and camera; LEGO Mindstorms NXT and LEGO Mindstorms EV3 Sets of reconfigurable mobile robots equipped with sensors and microcontrollers), Laboratory CeNT, University of Belgrade, Faculty of Mechanical Engineering, 18.12
[5] Laboratory model of designed manufacturing system, Laboratory CeNT, University of Belgrade, Faculty of Mechanical Engineering, 18.12

number of hours

lectures: 35
research: 0

assessment of knowledge (maximum number of points - 100)

feedback during course study: 15
test/colloquium: 0
laboratory exercises: 10
calculation tasks: 0
seminar works: 35
project design: 0
final exam: 40
requirements to take the exam (number of points): 40

references

Tensor Calculus

ID: PhD-3550

teaching professor: Zorić D. Nemanja

level of studies: Ph.D. (doctoral) studies

ECTS credits: 5

final exam: oral

goals

-to provide students knowledge of the fundamental principles and methods in Tensor Calculus
-to enable students to solve practical problems in Tensor Calculus using acquired knowledge in Tensor Calculus
-to prepare students to monitoring novelties in science and engineering

learning outcomes

-to enable students to master terms, methods and principles in Tensor Calculus
-to enable students to relate the knowledge from Tensor Calculus with knowledge in other scientific fields, to apply knowledge from Tensor Calculus in analysis, synthesis and prediction of solutions and consequences of problems in science

theoretical teaching


practical teaching


prerequisite

Defined by the curriculum study of Phd studies program.

learning resources


number of hours

lectures: 35
research: 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: 50
project design: 0
final exam: 50
requirements to take the exam (number of points): 30

references

Testing and optimization of machine tools

ID: PhD-3428

teaching professor: Živanović T. Saša

level of studies: Ph.D. (doctoral) studies

ECTS credits: 5

final exam: seminar works

goals

1) To receive basic knowledge about testing of machine tools and machining systems.
2) To receive basic knowledge about methods for machining system optimization.
3) To receive practical knowledge about virtual machining systems.
4) To receive training in testing procedures and optimization methods for machine tools and machining systems.
5) To know how to make technical projects.

learning outcomes

Upon successful completion of this course Students should be able to:

1. They plan and implement methods for testing machine tools and manufacturing systems.
2. Apply methods to optimize the machining system.
3. Configure virtual machining systems in the field of digital technology.
4. Make a choice to carry out integrated testing procedures and optimization methods for machine tools and machining systems.
5. Prepare by Technical Elaborate and reports about testing and optimization of the machining system.

theoretical teaching

New teaching contents:
1) Testing of machine tools and machining systems.
2) Methods for machining system optimization.
3) Virtual machining system and digital manufacturing.
4) Integrated methods for testing and optimization of machine tools and machining systems.
5) Modal analysis.

Elaboration of new teaching contents and instructions for doing the tasks:
1) Planning of one complex machining system testing.
2) Analysis of machining systems optimizations methods.
3) Examples of simulations in virtual machining system.
4) Examples of integrated methods for machine tools and machining systems optimization.
5) Examples of basic modal analysis.

practical teaching

Practical teaching involves laboratory work in Laboratory for machine tools and machining systems, and seminar work writing. Planned experiments are carried out in the Laboratory with finishing the reports. These reports are a part of the seminar work.

prerequisite

Study curriculum and student motivation for learning about testing and optimization of...
machine tools according to the goals set and outcomes offered.

**learning resources**

Laboratory for machine tools and machining systems, which includes both hardware and software:
1) Different kinds of sensors (accelerometers, dynamometers etc.).
2) The systems for experimental data conditioning and acquisition.
3) Software for experimental data processing.
4) The systems for laboratory testing of machine tools accuracy.
5) The system for circular interpolation test.
6) Test bed for identifying parameters of mechanistic cutting forces models.
7) Test bed for cutting process optimization, feed scheduling, and integrated simulation of machine tool and process.
8) Software for virtual machining system simulations.
9) Test bed for parallel kinematics machine tools.
10) Test bed for configuring and programming of modular open architecture machine tools (MOMA).
11) Test bed for the STEP-NC protocol based programming of CNC machines.
12) Hardware needed for basic modal analysis (modal hammer, accelerometers etc.).
13) Software for basic modal analysis.
14) Functional simulator of the rapid prototyping machine tool.
15) Software for basic optimization of machine tools structures.

**number of hours**

lectures: 35
research: 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: 70
project design: 0
final exam: 30
requirements to take the exam (number of points): 50

**references**

The integration of aeronautical systems and avionics

ID: PhD-3502

teaching professor: Petrović B. Nebojša

level of studies: Ph.D. (doctoral) studies

ECTS credits: 5

final exam: seminar works

goals

Modern aircrafts are extremely complex products comprised of many subsystems, components and parts. It is the integration of these components and their interaction and interconnection that determine the overall success of aircraft. The goal of this course is to:

- introduce students with the features of modern aircraft systems
- deepen their knowledge of major aircraft systems: flight control systems, engine and fuel control systems, hydraulic and pneumatic systems, electrical systems, environmental systems...
- introduce students to the emerging new systems and systems under development
- introduce students to the system design and development with emphasis on commercial and military aircraft examples
- investigate current-day avionics and features of modular integrated full glass cockpits.

learning outcomes

By successfully adopting the curriculum, a student:
- acquires fundamental understanding of systems engineering and architecture.
- have a working knowledge related to integrating an aircraft as a system.
- will acquire relevant experience in applying systems engineering concepts, processes and methodologies in the context of aircraft engineering.
- will gain insight into developing technologies and future trends in aircraft systems

theoretical teaching

-Introduction to systems engineering and development
-Flight control systems
-Engine and fuel control systems
-Hydraulic and pneumatic systems
-Electrical systems
-Environmental systems
-Advanced and developing aircraft systems
-Integration of aircraft systems: methodologies and tools used for integration of aircraft systems in order to deliver system that meets user requirements

practical teaching

Contents of lab exercises follow the exposed material. Students will be introduced to examples from industry and the practical problems in the development and integration of individual systems. Through modeling of specific components of the system students master the skills necessary to work in the field of aircraft system engineering. Introducing students to the relevant regulations, standards and methods of aircraft system engineering they are prepared for work in the profession.
prerequisite

There is no necessary requirement for attendance of The integration of aeronautical systems and avionics.

learning resources

Simlab - computer laboratory

number of hours

lectures: 35
research: 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: 70
project design: 0
final exam: 30
requirements to take the exam (number of points): 70

references

Moir I., Seabridge A., Aircraft Systems: Mechanical, Electrical and Avionics Subsystems Integration
Additional materials (written handouts, problem setting, guidelines for problem solving...)
Theory and Simulation of the Machining Process

ID: PhD-3283

teaching professor: Tanović M. Ljubodrag

level of studies: Ph.D. (doctoral) studies

ECTS credits: 5

final exam: written

goals

Theoretical considerations of the machining process and its phenomena, establishing its regularities as a prerequisite for solving problems of manufacturing engineering. Establishing the logic of theoretical modeling of machining real physical processes and development of program support for animation and simulation.

learning outcomes

The student should acquire knowledge and develop skills needed for advanced critical and self-critical approach to Theory and Simulation of the Machining Process. Solving of concrete problems by using scientific methods and procedures.

theoretical teaching

Basics of the machining process theory, Basic elements of the machining process, Material properties, Engineering materials, technology of powder metallurgy, Basics of shaping by plastic deformation, Software development for simulation and animation: cutting resistance in turning, drilling, boring, peripheral and face milling, heat in the cutting zone, grinding process, surface roughness, optimization of the turning and milling processes, machining process dynamics, Special processes and technologies.

practical teaching

Practical teaching involves laboratory work in Laboratory for machine tools and machining systems, and seminar work writing. Planned experiments are carried out in the Laboratory with finishing the reports. These reports are a part of the seminar work.

prerequisite

MSc degree, preferably in technical sciences.

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

lectures: 35
research: 0

assessment of knowledge (maximum number of points - 100)

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

references

Kalpakjian S., Manufacturing Engineering and Technology, Addison-Wesley Pub.Com., 1995
Tanović Lj., Petrakov Y.V., Theory and Simulation of the Machining Process, FME, Belgrade, 2007
Theory of elasticity

ID: PhD-3541  
teaching professor: Milošević-Mitić O. Vesna  
level of studies: Ph.D. (doctoral) studies  
ECTS credits: 5  
final exam: written+oral

goals

The purpose of this course is that students understand and learn the basic concepts of the theory of elasticity. They will acquire the basis of the tensor method, too. Students will enable to model and solve some reological problems. Through understanding the reological processes they will be able to use computer programs in this field.

learning outcomes

- By negotiation of this program, students will master some methods and procedures of theory of elasticity and tensor method.  
- They will be able to calculate stress components on the base of balance equations and to form appropriate tensors of stress and strain for an elastic body.  
- They will be introduced with principal stresses (intensity, position) and with maximum shear stress.  
- They will be able to calculate main strains.  
- Students will master application of hypothesis about the collapse of material.  
- They will understand elasticity and stiffness matrixes.  
- They will be able to solve some real problems related to thin plates.

theoretical teaching


practical teaching


prerequisite

Set by the Curriculum of the study program

learning resources
Handouts from the website of the Department for Strength of the constructions

**number of hours**

lectures: 35  
research: 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: 40  
project design: 0  
final exam: 50  
requirements to take the exam (number of points): 40  

**references**

Theory of elasticity, T. Atanacković  
Theory of elasticity, S. Tymoshenko, J. N. Gudier  
Sets of the structural strength, T. Maneski, V. Milosevic-Mitic, D. Ostric
Theory of gyroscopes

ID: PhD-3095

teaching professor: Jeremić M. Olivera

level of studies: Ph.D. (doctoral) studies

ECTS credits: 5

final exam: oral

goals

-to provide students knowledge of the fundamental principles and methods in Theory of gyroscopes
-to enable students to solve practical problems in engineering using acquired knowledge in Dynamics of variable mass systems
-to prepare students to monitoring novelties in science and engineering

learning outcomes

-to enable students to master terms, methods and principles in Theory of gyroscopes
-to enable students to relate the knowledge from Dynamics of variable mass systems with knowledge in other scientific fields, to apply knowledge from Dynamics of variable mass systems in analysis, synthesis and prediction of solutions and consequences of problems in science

theoretical teaching


practical teaching


prerequisite

Defined by the curriculum study of PhD studies program.
learning resources


number of hours

lectures: 35
research: 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: 50
project design: 0
final exam: 50
requirements to take the exam (number of points): 30

references

Theory of hydrodynamic stability

ID: PhD-3135
teaching professor: Lečić R. Milan
level of studies: Ph.D. (doctoral) studies
ECTS credits: 5
final exam: oral

goals

Gaining knowledge from linear and nonlinear theory of hydrodynamic stability, which gives the opportunity of own research in this area.

learning outcomes

Student will gain knowledge from theory of hydrodynamic stability. This knowledge can be used for scientific research in this area of fluid dynamics.

theoretical teaching


practical teaching

Calculations of linear stability problems in laminar flows.

prerequisite

Passed exam in Selected Chapters in Fluid Mechanics.

learning resources

number of hours

lectures: 35
research: 0

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): 0

references

Thermal-Hydraulics of Steam Generators

**ID:** PhD-3525  
**teaching professor:** Stevanović D. Vladimir  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** seminar works

**goals**

Mastering scientific and engineering methods for the prediction, analysis and investigation of thermal-hydraulic processes in the steam generators, as well as methods for the design and safety analyses of steam generator operational conditions.

**learning outcomes**

Students acquire knowledge and skills to simulate and analyse thermal-hydraulic processes in steam generators, including prediction of feedwater heating and boiling zones, pressure changes in single and two-phase flows, heat transfer to feedwater, conditions of boiling crisis occurrence, steam and liquid separation and other effects of two-phase flow in steam generators. Acquired knowledge enables prediction and analyses thermal-hydraulic processes within design and safety analyses of steam generators.

**theoretical teaching**


**practical teaching**

Development of a model of natural or forced circulation in the steam generator. Numerical solving of the model and simulation and analyses of operational conditions.

**prerequisite**

Passed exams in Thermodynamics, Fluid Mechanics and Higher Mathematics at Bachelor or Master university studies.

**learning resources**

Lecture notes, computer equipment, in-house and commercial computer codes for two-phase flow simulations.

**number of hours**

lectures: 35  
research: 0

**assessment of knowledge (maximum number of points - 100)**
feedback during course study: 10

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

references

Stevanovic, V., Thermal-Hydraulics of Steam Generators – Modelling and Numerical Simulation, University of Belgrade, Faculty of Mechanical Engineering, 2006.
Thermal Power Plant Engineering

**ID:** PhD-3388  
**teaching professor:** Petrović V. Milan  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written

**goals**

1. The achievement of research and expert competence in the field of thermal power engineering.  
2. The achievement of high level of theoretical knowledge  
3. The acquisition of research and expert knowledge in thermal power engineering  
4. The achievement of the techniques of process modeling.  
5. Mastering the methods of experimental work in thermal power engineering.

**learning outcomes**

1. Expert and research deep knowledge in thermal power engineering  
2. The development of critical thinking about energy use, fuel efficiency and environmental preservation  
3. The ability to design of the steam turbine power plants.  
4. Ability to use computer technology for modeling and calculations

**theoretical teaching**


**practical teaching**

Model and software development

**prerequisite**

PhD student - Thermal power engineering.

**learning resources**

Literature. Computing facilities

**number of hours**

lectures: 35  
research: 0

**assessment of knowledge (maximum number of points - 100)**

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

references

Stojanovic, Themal Turbomachinery, Gradjevinska knjiga, Belgrade, 1967.
Thermoelasticity

**ID:** PhD-3163  
**teaching professor:** Milošević-Mitić O. Vesna  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written+oral

**goals**

- The goal of this course is that students understand the nature of thermal load, to learn the basic terms of thermoelasticity and the tensor way of describing the problem.  
- Students will be trained to model and solve some problems of thermoelasticity.  
- Since many of machine constructions have designed based on beams and plates, special attention will be done on the elements of this form.  
- Through understanding the thermoelastic processes, students will be able to properly use computer programs in this field.

**learning outcomes**

- By completing the program of this course, students will learn some of the methods and procedures of scientific research.  
- They will introduce concepts of thermoelasticity, such as the balance of energy and entropy, the stress and strain tensor.  
- Students will be able to solve some specific problems by using modern analytical methods and numerical methods.  
- They will be introduced with the importance of the construction geometry and the appropriate boundary conditions on the construction behavior.  
- They will be able to relate and apply the acquired knowledge from different areas.

**theoretical teaching**

Introduction. Stress components in the Cartesian coordinate system. Stress tensor.  

**practical teaching**

Tensor marking method and some basic operations. Integral transform technique, finite Fourier transform and the Laplace transform. Plain state of stress and plain state of strain. Thermally loaded beams and thin plates. Application of analytical and numerical methods on solving problems of thermoelasticity.

**prerequisite**

Set by the Curriculum of the study program

**learning resources**

Handouts from the website of the Department for Strength of constructions
number of hours

lectures: 35
research: 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: 40
project design: 0
final exam: 50
requirements to take the exam (number of points): 40

references

Čukić R., Naerlović-Veljković N., Šumarac D., Thermoelasticity, Faculty of Mechanical Engineering, University of Belgrade
Čukić R., Solutions of some problems of thermoelasticity using integral transform technique, Scientific book, Belgrade
Nowacki W., Dynamic Problems of Thermoelasticity, P. W. N. Warszaw
Thin-walled structures

**ID:** PhD-3004  
**teaching professor:** Andelić M. Nina  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written+oral

goals

The aim of the course is that students learn about the problem of torsion of prismatic structural elements of arbitrary shapes and cross-sections, and then with thin-walled structural elements of open and closed cross-sections. Also introduce students to the basics of the theory of thin plates with the problem of losing their stability.

learning outcomes

By mastering the study program of this course the student acquires the ability to independently:

- Account distribution of stress and strain in structures of arbitrary cross-sectional shape that are exposed how complicated twisting and straining
- Determines the geometrical characteristics of sectoral cross-sections of arbitrary shape
- Dimensioned load-bearing structural elements using different criteria in the field of theories of strength
- Solve concrete problems using scientific methods and procedures
- Connects basic knowledge in various fields with the aim of further application in practice, by using computer programs

theoretical teaching


practical teaching

Calculation of torsional characteristics of arbitrary and thin-walled cross-sections, the determination of the relevant geometrical properties of the considered cross-sections. Determination of the stress and strain for the cross-sections discussed in the theoretical teaching.

prerequisite

Set by the Curriculum of the study program.
learning resources

1. Handouts from the website of the Department.

number of hours

lectures: 35
research: 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: 40
project design: 0
final exam: 50
requirements to take the exam (number of points): 40

references

D. Ružić, R. Čukić, M. Dunjić, M. Milovančević, N. Andelić, V. Milošević-Mitić: Strength of matherials-Tables, University of Belgrade, Faculty of Mechanical Engineering, Belgrade, 2015
Ružić, D., Strength of Structures (in Serbian), University of Belgrade, Faculty of Mechanical Engineering, Belgrade, 1995
Kollbruner, C.F., Hajdin, N., Dunnwandige Stabe, Band 1, Springer Verlag, Berlin, 1970
Thrust Vector Control Systems

**ID:** PhD-3519  
**teaching professor:** Miloš V. Marko  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** seminar works

**goals**

Acquisition of specific knowledge of the Thrust Vector Control (TVC) systems applied to the solid propellant rockets and liquid propellant rockets.  
Objective of the course is providing insight in the physics of the nozzle flow and solutions to provide directional control of missiles, spacecraft and launch vehicles.

**learning outcomes**

Engineers will be able to make proper selection of the vehicle flight-control system that must perform two functions: fly the vehicle along a commanded trajectory & maintain vehicle flight stability in the atmosphere.  
Gained knowledge will be sufficient for initial design of various types of TVC systems.

**theoretical teaching**

1. Nozzle – different configurations  
2. Nozzle – processes inside  
3. Nozzle – CFD & Engineering solutions  
4. Nozzle – case study  
5. Missile Flight Control Systems  
6. Classification of TVC systems  
7. TVC - Criteria for Comparison  
8. Jet Vane, Jetavator, Axial Jet Deflector & Beveled Nozzle Concept  
9. Dome Deflector, Jet Tab  
10. Impulse Winglet in Rocket Motor Efflux  
11. Gimbaled LRE  
12. Fundamentals of Actuating Sustems  
13. Secondary Fluid Injection  
14. Movable Nozzle TVC System - Split Line Classification, Classification Due to the Pivot Point  
15. Movable Nozzle TVC System - Classification Due to the Position of Hinge Line, Classification Due to the Type of Nozzle Joint Assembly  
16. Stress Analysis & Selection of Materials  
17. Testing & verification of TVC Systems  
18. TVC– case study

**practical teaching**

Exercises include presentation of gimbaled LRE TVC system and actuator systems.  
Upon completion of calculation and simulation - practical work with TVC system and actuator: measurement of certain parameters and presentation of control.  
Also, visiting to:  
1. Military Technical Institute – Solid Propelant Rocket Motor Laboratory  
2. Department of Automatic Control of Faculty of Mechanical Engineering.
3. Laboratory for Hybrid Systems - Faculty of Mechanical Engineering

**prerequisite**

Using of MATLAB® i Simulink®.
Using of CFD software (any).
Using of 3D CAD design software (any) – preferable, not obligatory

**learning resources**

Moodle (Modular Object-Oriented Dynamic Learning Environment, a free, open-source PHP web application for producing modular internet-based courses that support a modern social constructionist pedagogy).
Lectures, power point presentations, room equipped with computers & software for design and simulations, labs, handouts.

**number of hours**

lectures: 35
research: 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: 70
project design: 0
final exam: 30
requirements to take the exam (number of points): 0

**references**

M.Milos, Thrust Vector Control Systems, professor's handouts
Thrust Vector Control Systems - Selected Topics

**ID:** PhD-3554  
**teaching professor:** Miloš V. Marko  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written

**goals**

Acquisition of specific knowledge of the Thrust Vector Control (TVC) systems applied to the solid propellant rockets and liquid propellant rockets. Objective of the course is providing insight in the physics of the nozzle flow and solutions to provide directional control of missiles, spacecraft and launch vehicles.

**learning outcomes**

Engineers will be able to make proper selection of the vehicle flight-control system that must perform two functions: fly the vehicle along a commanded trajectory & maintain vehicle flight stability in the atmosphere. Gained knowledge will be sufficient for initial design of various types of TVC systems.

**theoretical teaching**

1. Nozzle – different configurations  
2. Nozzle – processes inside  
3. Nozzle – CFD & Engineering solutions  
4. Nozzle – case study  
5. Missile Flight Control Systems  
6. Classification of TVC systems  
7. TVC - Criteria for Comparison  
8. Jet Vane, Jetavator, Axial Jet Deflector & Beveled Nozzle Concept  
9. Dome Deflector, Jet Tab  
10. Impulse Winglet in Rocket Motor Efflux  
11. Gimbaled LRE  
12. Fundamentals of Actuating Systems  
13. Secondary Fluid Injection  
14. Movable Nozzle TVC System - Split Line Classification, Classification Due to the Pivot Point  
15. Movable Nozzle TVC System - Classification Due to the Position of Hinge Line, Classification Due to the Type of Nozzle Joint Assembly  
16. Stress Analysis & Selection of Materials  
17. Testing & verification of TVC Systems  
18. TVC – case study

**practical teaching**

Exercises include presentation of gimbaled LRE TVC system and actuator systems. Upon completion of calculation and simulation - practical work with TVC system and actuator: measurement of certain parameters and presentation of control. Also, (optional) visiting to:  
1. Military Technical Institute – Solid Propellant Rocket Motor Laboratory  
2. Department of Automatic Control of Faculty of Mechanical Engineering.
prerequisite

Using of MATLAB® & Simulink®.
Using of CFD software (any).
Using of 3D CAD design software (any) – preferable, not obligatory

learning resources

Moodle (Modular Object-Oriented Dynamic Learning Environment, a free, open-source PHP web application for producing modular internet-based courses that support a modern social constructionist pedagogy).
Lectures, power point presentations, romm equipped with computers & software for design and simulations, labs, handouts.

number of hours

lectures: 35
research: 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: 70
project design: 0
final exam: 30
requirements to take the exam (number of points): 0

references

1. M.Milos, Z.Stefanovic, Thrust Vector Control Systems, professor’s handouts
**Topics in Thermodynamics of Thermal Energy Conversion**

**ID:** PhD-3551  
**teaching professor:** Petrović V. Milan  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written

**goals**

1. The achievement of research and expert competence in thermodynamic for in thermal power engineering.  
2. The achievement of high level of theoretical knowledge  
3. The acquisition of research and expert knowledge thermodynamic for in thermal power engineering.  
4. The achievement of the techniques of process modeling.  
5. Mastering the methods of experimental work in thermal power engineering.

**learning outcomes**

1. Expert and research deep knowledge of the thermodynamic cycle in thermal power engineering  
2. The development of critical thinking about energy use, fuel efficiency and environmental preservation  
3. Ability to use computer technology for modeling and calculations

**theoretical teaching**


Thermodynamic improvement of gas turbine cycles. Steam turbine power cycles.

**practical teaching**

Exercises.

**prerequisite**

PhD Student - Thermal power engineering

**learning resources**

Literature, computing facility

**number of hours**

lectures: 35  
research: 0

**assessment of knowledge (maximum number of points - 100)**
feedback during course study: 10
test/colloquium: 40
laboratory exercises: 0
calculation tasks: 10
seminar works: 0
project design: 0
final exam: 40
requirements to take the exam (number of points): 50

references

H. D. Baehr, S. Kabelac: Thermodynamik: Grundlagen Und Technische Anwendungen
Turbomachinery Flow Phenomena - Computational Fluid Dynamics

**ID:** PhD-3193  
**teaching professor:** Nedeljković S. Miloš  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** seminar works

**goals**

Mastering calculation methods for the prediction of flow through complex turbomachinery geometries.

**learning outcomes**

Mastering calculation methods for the prediction of flow through complex turbomachinery geometries.

**theoretical teaching**


**practical teaching**

Numerical exercises when needed

**prerequisite**

Knowledge of turbomachinery advanced courses, numerical methods, algorithms and programming.

**learning resources**

**number of hours**

- lectures: 35  
- research: 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: 70  
- project design: 0  
- final exam: 30  
- requirements to take the exam (number of points): 70
references

Fletcher CAJ. Computational Techniques for Fluid Dynamics I and II. Springer-Verlag, Berlin 1991
Turbomachinery Flow Phenomena - Design of Cascades and Impeller Blades

ID: PhD-3194
Teaching professor: Nedeljković S. Miloš
Level of studies: Ph.D. (doctoral) studies
ECTS credits: 5
Final exam: seminar works

Goals

Mastering calculation methods of turbomachinery design.

Learning outcomes

Mastering calculation methods of turbomachinery design.

Theoretical teaching


Practical teaching

Practical design example

Prerequisite

Knowledge of turbomachinery advanced courses, numerical methods, algorithms and programming.

Learning resources

Number of hours

Lectures: 35
Research: 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: 70
Project design: 0
Final exam: 30
Requirements to take the exam (number of points): 70

References
Turbulent flow measurements

**ID:** PhD-3409  
**teaching professor:** Čantrak S. Đorđe  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** seminar works

**goals**

The goal of this course is to introduce students in measurements of the physical quantities in turbulent flows, by use of classical and contemporary measurement techniques. Measurements in turbulent flows are essentially correlated to the physical understanding of Reynolds equations and necessity for turbulence modeling. The main goal of this course is introducing the principles of laser based measurement techniques to students, such as Laser Doppler anemometry and Particle image velocimetry (PIV), as well with fundamentals of other optical anemometer methods.

**learning outcomes**

Upon successful completion of this course, doctoral students should be able to:
1. use the following anemometry methods: laser Doppler anemometry (LDA), particle image velocimetry (PIV), hot-wire anemometry (HWA) probes, as well as other classical methods,  
2. measure the pressure field in the fluid,  
3. calculate the integral and statistical parameters of turbulence based on the measurement results,  
4. perform data acquisition with modern measurement and acquisition systems, as well as their statistical analysis.

**theoretical teaching**


**practical teaching**

2. Plane and stereo PIV calibration.  
3. PIV measurements.  
4. Application of algorithms for analysis of experimental data obtained by PIV.  
5. Data processing and analysis of LDA measured data.  

**prerequisite**
Doesn't exist. Advice for the second semester: Selected chapters from Fluid Mechanics.

**learning resources**

1. Textbooks listed in the references and list of literature provided for students.
2. Čantrak S., Turbulent Flows, lecture handouts on Ph.D. (doctoral) studies, Faculty of Mechanical Engineering University of Belgrade, Belgrade.
3. Benišek M., Fluid Measurements, lecture handouts on Ph.D. (doctoral) studies, Faculty of Mechanical Engineering University of Belgrade, Belgrade.
4. Lecture handouts.
5. Experimental test rigs and equipment in the Laboratory for hydraulic machines and energy systems.

**number of hours**

lectures: 35  
research: 0

**assessment of knowledge (maximum number of points - 100)**

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

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

**references**

Turbulent flows

**ID:** PhD-3138  
**teaching professor:** Lečić R. Milan  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written+oral

**goals**

To provide necessary theoretical framework for physical understanding and mathematical modelling of turbulent flows.

**learning outcomes**

Student will have good theoretical framework for physical understanding and mathematical modelling of turbulent flows.

**theoretical teaching**


**practical teaching**

Analysis of experimental and DNS data of turbulent flows. Using Python and R modules for statistical analysis.

**prerequisite**

Passed exam in Selected topics in Fluid Mechanics on PhD studies.

**learning resources**

**number of hours**

lectures: 35  
research: 0

**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): 30

references

Peter Davidson: Turbunce, an introduction for scientists and engineers, Oxford University Press
Vehicle Mechatronics - Special Chapters

**ID:** PhD-3217  
**teaching professor:** Popović M. Vladimir  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written+oral

**goals**

Course objectives are designed to meet the needs of the 21st Century automotive industry for graduate students with the necessary skills and understanding in mechatronics. Students should be able to deal with a wide range of activities that include research, design, development and testing of mechatronic systems in motor vehicles.

**learning outcomes**

Students obtain the following general ability:
- analysis, synthesis and forecast of solutions and consequences  
- mastering the methods, procedures and processes of research,  
- application of the acquired knowledge in practice.

Students also acquire subject-specific skills:
- through introduction to vehicle mechatronic systems,  
- by solving concrete problems by using scientific and engineering methods and procedures,  
- development of the skills for the use of knowledge in the field of mechatronics within the vehicle.

**theoretical teaching**

The four main teaching blocks include following areas: (a) Introduction to mechatronics and basic mechatronic systems, (b) vehicle mechatronic systems - general (control systems and automation, dynamics, sensors, micro-electronics, actuators, central computer unit), (v) specific characteristics of mechatronic system within the vehicle (braking system, suspension system, power transmission system, integrated vehicle systems) and (g) examples of vehicle mechatronic systems.

**practical teaching**

The four main teaching blocks include following areas: (a) Introduction to mechatronics and basic mechatronic systems, (b) vehicle mechatronic systems - general (control systems and automation, dynamics, sensors, micro-electronics, actuators, central computer unit), (v) specific characteristics of mechatronic system within the vehicle (braking system, suspension system, power transmission system, integrated vehicle systems) and (g) examples of vehicle mechatronic systems.

**prerequisite**

No special requirements.

**learning resources**

1. Class room  
2. Other author book
3. Foreign language books
4. Other literature
5. IT Hardware
6. IT software

**number of hours**

lectures: 35
research: 0

**assessment of knowledge (maximum number of points - 100)**

feedback during course study: 10
test/colloquium: 30
laboratory exercises: 0
calculation tasks: 10
seminar works: 20
project design: 0
final exam: 30
requirements to take the exam (number of points): 60

**references**

B. Vasic, V. Popovic: Vehicle Mechatronics (at prepress).
Waste management and research

ID: PhD-3096  
teaching professor: Jovović M. Aleksandar  
level of studies: Ph.D. (doctoral) studies  
ECTS credits: 5  
final exam: seminar works

goals

The aim of this course is introducing the candidates with problems and problem solving in the field of waste management with respective scientific methods; subject is designed as an advanced course in the area of waste management at the level of doctoral studies.

learning outcomes

At the end of the course it is expected that the candidate has mastered the scientific knowledge pertaining to the analysis and evaluation of scientific papers, ways and methods of analysis of certain waste management procedures, laboratory work, as well as advanced process modeling in the area of municipal waste management system, thermal and biological waste treatment, methods of waste depositing and landfill gas generation.

theoretical teaching


practical teaching

If needed laboratory work and visits to industrial facilities.

prerequisite

There is no previous requirements for attending this course.

learning resources

Laboratory facility / installation / machine (LFI):
1. laboratory facility for wastewater treatment research
2. laboratory facility for thermal treatment of waste and other facilities and installations if needed.

number of hours

lectures: 35  
research: 0

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assessment of knowledge (maximum number of points - 100)

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

references

Papers from Journals Waste Management and Research, Waste Management, etc.
**Water waves**

**ID:** PhD-3159  
**teaching professor:** Milićev S. Snežana  
**level of studies:** Ph.D. (doctoral) studies  
**ECTS credits:** 5  
**final exam:** written

**goals**

The goal of this course is to acquire knowledge about the fundamental aspects of the water wave’s phenomena and mastering of mathematical methods for modeling these flows present in a variety of practical problems.

**learning outcomes**

Students are trained to develop mathematical models of water waves with contemporary and scientific methods. Also they are prepared to solve the relevant problems by analytical and numerical methods.

**theoretical teaching**

Theoretical lessons incorporate the basic laws that describe the water wave’s phenomenon which includes several specific studies of the linear and nonlinear waves. Linear problems include description of waves on sloping beaches, as well as the phenomenon of edge waves. Some general ideas associated with ray theory are developed also and its results are applied to variable depth, ship waves, and waves on currents. Under the nonlinear problems, the application to waves on a sloping beach is extended in order to include the effects of nonlinearity. The Stokes expansion which produces higher approximations to the classical linear wave is described also. The fully nonlinear solitary wave is considered too. Explanation of the analogy between nonlinear water waves and (nonlinear) gas dynamics is given.

**practical teaching**

Practical lessons contain application of analytical and numerical results for different models of linear and nonlinear water waves.

**prerequisite**

Passed exam in Fluid mechanic and Thermodynamics.

**learning resources**

Course handouts.

**number of hours**

lectures: 35  
research: 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: 50
project design: 0
final exam: 50
requirements to take the exam (number of points): 50

references

A Modern Introduction to the Mathematical Theory of Water Waves, R. S. Johnson,
Cambridge University Press, October 28, 1997
Linear Water Waves: A Mathematical Approach, N. Kuznetsov, V. Maz'ya, B. Vainberg,
Cambridge University Press; 1 edition (August 19, 2002)
Wave Induced Loads on Ships

ID: PhD-3187
teaching professor: Motok D. Milorad
level of studies: Ph.D. (doctoral) studies
ECTS credits: 5
final exam: seminar works

goals

Learning basic theory and practical procedures for calculation of wave induced shear forces and bending moments on ship hulls.

learning outcomes

Student should be capable of conducting calculations of wave induced shear forces and bending moments on ship hulls using commercial software tools.

theoretical teaching

Derivation and solving differential equations of Salvesen, Tuck and Faltinsen for combined heave and pitch - up to values of shear force and bending moment along ship.

practical teaching

Numerical methods for solving differential equations of Salvesen, Tuck and Faltinsen for combined heave and pitch. Getting acquainted with commercial software in the field.

prerequisite

Defined by the curriculum of studies. Successfully finished course in Sea-keeping on doctoral studies.

learning resources

Commercial software in the field.

number of hours

lectures: 35
research: 0

assessment of knowledge (maximum number of points - 100)

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

references

498
Jorgen Juncker Jensen: Load and Global Response of Ships, Technical University of Denmark, 2000
The dynamics of a viscous incompressible fluid

ID: PhD-3500  
teaching professor: Lečić R. Milan  
level of studies: Ph.D. (doctoral) studies  
ECTS credits: 5  
final exam: written

goals

To develop and rationalize the mathematics of viscous fluid flow using basic principles, such as mass, momentum and energy conservation, and constitutive equations and to exhibit the systematic application of these principles to flows occurring in fluid processing and other applications.

learning outcomes

Student will develop and rationalize the mathematics of viscous fluid flow using basic principles, such as mass, momentum and energy conservation, and constitutive equations and to exhibit the systematic application of these principles to flows occurring in fluid processing and other applications.

theoretical teaching

practical teaching


prerequisite

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learning resources

-

number of hours

lectures: 35
research: 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): 0

references

Tasos C. Papanastasiou, Georgios C. Georgiou, Andreas N. Alexandrou: VISCIOUS FLUID FLOW, CRC Press LLC 2000