University of Belgrade

Faculty of Mechanical Engineering

Course catalog

Ph.D. (postgraduate) academic studies – Mechanical Engineering

Belgrade

2022.

TABLE OF CONTENTS

Actuating Systems - Selected Topics

ID: PhD-3553
responsible/holder professor: Miloš V. Marko
teaching professor/s: Miloš V. Marko
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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. Contol 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.

lecture hours of active teaching: 35

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 – McGraww-Hill
A. VanDoren, Data Acquisition Systems, Reston Publishing Co., Inc.
N. Avgoustinov: Modelling in Mechanical Engineering and Mechatronics – Springer, 2007
W. Bolton: Mechatronics-Electronic Control Systems in Mechanical and Electrical Engineering – Pearson, 2012

Adaptive Structures

ID: PhD-3254
responsible/holder professor: Simonović M. Aleksandar
teaching professor/s: Dinulović R. Mirko, Simonović M. Aleksandar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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

lecture hours of active teaching: 35

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
D. Wagg, I.Bond, P.Weaver, M.Friswell, ADAPTIVE STRUCTURES: ENGINEERING APPLICATIONS, Wiley, 2007
M.Wiedemann, M.Sinapius, ADAPTIVE, TOLERANT AND EFFICIENT COMPOSITE STRUCTURES, Springer, 2013
A.V. Srinivasan, D.M. McFarland, SMART STRUCTURES - ANALYSIS AND DESIGN, Cambridge University Press, 2001.
T.H.Brockmann, THEORY OF ADAPTIVE FIBER COMPOSITES, Springer, 2009
Selected Journal Articles

Advance techniques in IC engines – selected topics

ID: PhD-3423
responsible/holder professor: Popović J. Slobodan
teaching professor/s: Popović J. Slobodan
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Understanding the reality and complexity of Heat Engines working cycles. Capabilities to design complex models and sub-models structures using multidisciplinary approach. Capabilities to analyse engine processes and performance using advanced simulation models. Establishing the Cause & Effect relationship between working cycle and engine performance.

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.

2. Gas flow in intake and exhaust ports and collectors. 1-D modelling of dynamic gas flow in pipes. Optimization of Intake and exhaust plenum geometry by maximizing engine volumetric efficiency.

3. Mechanical losses in IC engines. Modelling engine friction and auxillaries power consumption. Experimental determination of mechanical losses distribution.

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

2. 1-D gas dynamics – Model governing equations and structure development, analysis and demonstration using commercial software packages. Solution methods and boundary conditions (comparative analysis of constant pressure charging, Fill and Empty technique, Wave-Action Method). Project task: Development, tuning and application of 1-D model of gas flow in IC engine collectors and ports.

3. Engine mechanical losses modelling - Global models. Detailed empirical and analytic angle resolved dynamic models. Prediction of engine performance by means of combined modelling of engine combustion and mechanical losses. Laboratory task: Measurement of friction losses in engine cylinder-piston assembly and bearings. Project task: Development, tuning and application of an engine friction model.

4. In-cylinder and port flow multidimensional modelling using CFD. Gas flow in complex geometry combustion chamber - simulation example. Laboratory task: Flow field characterization in engine ports and combustion chambers. Project task: Multidimensional model of gas flow in engine plenums and ports - model development in CFD software package and its application.

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 equipпed IC Engine test benches)

DAQ Measurement equipment (National Instruments PXI based system with LabView Development software)

lecture hours of active teaching: 35

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

J. Heywood: Internal combustion engines fundamentals, McGraw-Hill 1988, ISBN 9780-070-28637-5
F. Pischinger: Verbrennungskraftmaschinen Thermodynamic, Springer Verlag, ISBN 978-3211836798
G. P. Merker et. al.: Simulating combustion and pollutant formation for engine development, Springer Verlag, ISBN 10 3-540-25161-8, 13 978-3-540-25161-3
R. Benson: The Thermodynamics and Gas Dynamics of Internal Combustion Engines, Vol 1, Vol. 2, Clarendon Press, Oxford, 1982, ISBN 0-19-856210-1
G. Stiech: Modeling Engine Spray and Combustion Process, Springer Verlag, ISBN 3-540-00682, 2003

Advanced Airframe Structural Analysis

ID: PhD-3457
responsible/holder professor: Grbović M. Aleksandar
teaching professor/s: Grbović M. Aleksandar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
1. The Fundamentals of Structural Analysis: Review.

2. Introduction to the Theory of Elasticity: Review.

3. Engineering Theory for Straight, Long Beams.

4. Work and Energy Principles. Advanced methods.

5. Energy-Based Numerical Solutions.

6. Introduction to the Finite Element Method and Extended FEM.

7. Basic Aspects of Multidimensional Finite Elements.

8. Thin Plate Theory and Structural Stability. Advanced methods.

9. Elastic and Aeroelastic Instabilities.

10.Beam Bending and Torsion, Beam Shearing Stresses. Example Problems. "Classical" and

"modern" methods of analysis.

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.

lecture hours of active teaching: 35

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.
Donaldson, Bruce: Analysis of aircraft structures, Cambridge Aerospace Series, 2008.

Advanced computer aided design

ID: PhD-3455
responsible/holder professor: Grbović M. Aleksandar
teaching professor/s: Grbović M. Aleksandar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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.

lecture hours of active teaching: 35

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.
Catia V5 Workbook: Release 14; Richard Cozzens, SDC Publications, 2006.

Advanced course in mathematics

ID: PhD-3398
responsible/holder professor: Radojević L. Slobodan
teaching professor/s: Aranđelović D. Ivan, Radojević Lj. Slobodan
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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 R^n and C^n. Linear Equations.
2. Matrices. Groups.
3. Vector spaces and subspaces. Basis and dimension.
4. Eigenvalues and eigenvectors.
5. General concepts of partial differential equations.
6. Partial equations of the first order. Homogeneous linear equations of the first order. Quasi-linear partial equations of the first order. Lagrange method.
7. Partial equations of second order. Classification of second order linear equations. One-dimensional wave equation. Two-dimensional wave equation.
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.

lecture hours of active teaching: 35

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
Meyer C.D., Matrix Analysis and Applied Linear Algebra, www.matrixanalysis.com/

Advanced Course in Numerical Methods for Ship Strength Analyses

ID: PhD-3188
responsible/holder professor: Motok D. Milorad
teaching professor/s: Motok D. Milorad
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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 emphasises 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/

lecture hours of active teaching: 35

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
M. Motok: Ship Strength /In Serbian/, MF, Beograd 1995.
O.F. Hughes: Ship Structural Design, John Wiley & Sons, New York,1983.
C.T.F Ross: Advanced Applied Finite Element Methods, Harwood Publishing, Chichester,1998.
Ever J. Barbero: Finite Element Analyses of Composite Materials,Taylor & Francis Group, LLC, Boca Raton, 2008.

Advanced course in pumps, fans and turbocompressors

ID: PhD-3597
responsible/holder professor: Čantrak S. Đorđe
teaching professor/s: Čantrak S. Đorđe
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
ECTS credits: 5
final exam: oral

goals
This course will provide detailed explanation of theoretical background of fluid flow in rotodynamic pump, fan and turbocompressors, as well as in their systems. Vital elements of these machines construction such as impeller, seals and bearings will be discussed, as well as their impact on the system reliability and availability. Various energy efficiency issues will be discussed. Methods of cost analysis, commissioning, operating , maintenance and disposal costs will be, also, discussed.

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

1.understand technical features of rotodynamic pumps, fans and turbocompressors (PFTC), their capabilities, as well as their limitations,

2.be familiar with principles of PFTCs design,

3.be familiar with proper use of methods of testing, diagnosing and estimation of the efficiency according to the international standards and codes,

4.be acquainted with the best practices and techniques of solving problems in operation such as cavitation and corrosion for pumps, vibration, erosion for PFTCs, and etc.

theoretical teaching
Fundamental principles of rotodynamic pump, fan and turbocompressor (PFTC). Energy efficiency of PFTC machines and systems. Principles of selection of right PFTC. Installation, commissioning and start up procedure for PFTC. Maintenance and troubleshooting. Various methods of PFTC performance regulation. Overall life-cycle cost and optimization of operation and maintenance costs.

practical teaching
1. Laboratory exercises: testing, application and regulation of the pumps. Determination of the system and machine duty points.

2. Calculation examples - Thermodynamic analysis for turbocompressors.

3. Various examples and case studies for PFTCs.

prerequisite
Familiarity with fluid mechanics, turbomachinery and turbulence.

learning resources
1. Textbooks listed in the references and list of literature provided for students.

2. Lecture handouts.

3. Scientific papers.

4. Experimental test rigs and equipment in the Laboratory for hydraulic machinery and energy systems.

lecture hours of active teaching: 35

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

Protić Z., Nedeljković M. (2010): Pumps and fans, Problems, solutions, theory, 6th edition, Faculty of Mechanical Engineering, Belgrade (in Serbian).
Logan E. Jr. (1993): Turbomachinery, Basic theory and applications, 2nd edition, Marcel Dekker, Inc., New York
Gülich J. F. (2020): Centrifugal pumps, 4th edition, Springer Nature Switzerland AG.
Editors Bommes L., Fricke J., Grundmann R. (1997): Ventilatoren, 2nd edition, Vulkan-Verlag, Essen (in German).
Pfleiderer C. (1955): Die Kreiselpumpen für Flüssigkeiten und Gase, Wasserpumpen, Ventilatoren, Turbogebläse, Turbokompressoren, Springer (in German).

Advanced course of hydromechanical equipment in hydro-energy systems

ID: PhD-3595
responsible/holder professor: Ilić B. Dejan
teaching professor/s: Ilić B. Dejan
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
ECTS credits: 5
final exam: seminar works

goals
The main aim of the course is to refer the students in the specific fields of energy and cavitation characteristics determination of hydromechanical equipment.

learning outcomes
Obtaining the knowledge of the energy and cavitation characteristics determination of hydromechanical equipment (valves, conical diffuser and etc.).

theoretical teaching
Characteristics of hydromechanical equipment. Flow through valves and trash-rack. Energy and cavitation characteristics determination of hydraulic valves. Axial and swirl turbulent flow in conical diffusers. Flow separation in a diffusers. Determination of swirl flow loss coefficients in conical diffusers.

practical teaching
Measurement of energy and cavitation characteristics of the valves. Experimental measurements of the axial and swirl turbulent flow in conical diffusers.

prerequisite
No prerequisites.

learning resources
[1] Hand-outs.

[2] Experimental test rigs and equipment in the Laboratory.

lecture hours of active teaching: 35

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): 30

references
J. Paul Tulis, Hydraulics of pipelines: Pumps, Valves, Cavitation, Transients, 1989.

Advanced Fuzzy Control Systems

ID: PhD-3411
responsible/holder professor: Jovanović Ž. Radiša
teaching professor/s: Jovanović Ž. Radiša
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
ECTS credits: 5
final exam: project design

goals
•Understanding of fuzzy approach to modeling, identification and control of process and systems

•Introduction to analysis and synthesis various fuzzy control algorithms

•Analysis, design, simulation and experimental realization of fuzzy control systems using Matlab/Simulink and LabView software.

learning outcomes
Knowledge and understanding of:

•Fuzzy identification of systems

•Analysis and design of ndirect and direct adaptive fuzzy controllers

•Analysis and design of fuzzy sliding mode controllers

•Analysis and design of fuzzy supervisory controllers

•Stability of fuzzy systems

•Siimulation and practical realization of fuzzy control systems using PC and programing software C, Matlab/Simulink and LabView with various automatic control plants.

theoretical teaching
Relation to identification, estimation, and prediction. Batch least squares and recursive least squares methods. Gradient methods. Clustering methods. Fuzzy control as sliding control: analysis and design. Design of the direct and indirect adaptive fuzzy controller. Stability and convergence analysis. Fuzzy supervisory control. Fuzzy gain scheduling. Stability of fuzzy systems: direct and indirect Lyapunov's method.

practical teaching
PA:

Fuzzy identification. Analysis and synthesis of various fuzzy control algorithms based on sliding mode control, tracking control, adaptive control and supervisory control.

PL:

Matlab, Simulink, Fuzzy and Identification toolbox. Design and simulation conventional and nonconventional fuzzy control algorithms using Matlab. Practice and experiments: realization of fuzzy control systems of electrohydraulic servosystem and various automatic control plants using PC, PLC and programming software Matlab and LabView.

prerequisite
Defined by curriculum of the study programme.

learning resources
•Modular educational real time control system with various control plants (DC servo motor, inverted pendulum, double inverted pendulum, heat flow experiment, coupled water tanks experiment), with acquisition hardware and software,

•Electrohydraulic control system,

•PC and PC Embedded controllers, Siemens Simatic PLC, National Instruments controllers,

• Installation for control system testing and acquisition of electrical variables,

•Automatic Control Laboratory, Intelligent Control Systems Laboratory, Control Systems Laboratory.

lecture hours of active teaching: 35

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

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

Advanced Gas Dynamics

ID: PhD-3556
responsible/holder professor: Bengin Č. Aleksandar
teaching professor/s: Bengin Č. Aleksandar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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-distanceand 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

lecture hours of active teaching: 35

assessment of knowledge (maximum number of points - 100)
feedback during course study: 10
test/colloquium: 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 Gasdynamics

ID: PhD-3565
responsible/holder professor: Milićev S. Snežana
teaching professor/s: Milićev S. Snežana, Ćoćić S. Aleksandar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Basic concepts. Basic equations. Continuity, momentum and energy equation. The concept of entropy. General theorems of gas dynamics. Disturbances of the final intensity. The normal shock wave. Oblique shock waves. Interaction and reflection of shock waves. Prantdl-Mayer expansion.

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

Non-isentropic flow. The influence of friction in the flows of gas in the pipes. Adiabatic and isothermal flow with friction. Flow with heat transfer.Characteristics of sonic flow over a body. Critical Mach number. Boundary layer. Interaction of shock waves and boundary layer.

Experimental methods and devices. Methods for flow visualization. Various types of wind tunnels. Basic methods for measuring pressure and temperature. Anemometric methods.

practical teaching
Application of the basic equations of gas flow. Speed of sound. Critical and total values of physical quantities. Assessing the impact of compressibility.

Isentropic gas flow. Calculation of normal shock wave. Conditions for the formation of oblique shock wave. Calculation of oblique shock wave. Calculation of gas flow through a sequence of shock waves. Interaction of shock waves in the flow field. Prandtl-Mayer expansion. Non-linearized airfoil theory. Calculation of the forces exerted by the fluid on airfoil in super-sonic flow.

Calculation of flow through the nozzle. Flow through convergent nozzle. Flow through de Laval nozzle. Supersonic diffuser. Determining the value of reactive force.

Non-isentropic flows. Calculation of adiabatic flows of viscous gas. Calculation of isothermal flow of viscous gas. Calculation of inviscid flows with heat transfer.

Linearized airfoil theory.

prerequisite
Passed exam in course Fluid Mechanics and Thermodynamics

learning resources
1.Handouts; 2. Tables for calculation of compressible flows with theoretical handouts, Snežana S. Milićev, Aleksandar S. Ćoćić, Faculty of Mechanical Engineering, 2017.

lecture hours of active teaching: 35

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.
Modern Comp ressible Flow: With Historical Perspective, Anderson, McGraw Hill.
Compressible Fluid Flow, M. A. Saad

Advanced Intelligent Control Systems

ID: PhD-3618
responsible/holder professor: Jovanović Ž. Radiša
teaching professor/s: Jovanović Ž. Radiša
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
ECTS credits: 5
final exam: project design

goals
This course is intended to provide students with an in depth understanding of the machine learning and artificial intelligence algorithms, as well as advanced issues of intelligent control systems:

- artificial intelligence methods based systems identification and control techniques and their applications in development of intelligent control systems;

- artificial intelligence methods based classification and recognition techniques and their applications.

After the course, the students will be able to apply the learned knowledge to solve problems in their respective research fields.

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

•understand of the functional operation of a variety of intelligent control techniques

•understand the theoretical foundations of intelligent control methods from the point of view of identification and control of dynamic systems.

•Carry out synthesis and analysis of intelligent control systems based on combinations of various theories: simulation, neural networks, fuzzy systems, genetic algorithms, evolutionary algorithms, etc.

theoretical teaching
Introduction to artificial neural networks. Feedforward neural networks. Recurrent neural networks. Radial basis function neural network. Support vector machines. Self-organizing map neural network. Artificial neural networks based identification of nonlinear systems. Artificial neural networks based control of nonlinear systems. Artificial neural networks based image recognition and pattern classification. Genetic algorithm. Evolutionary algorithms. Neuro-fuzzy systems.

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 intelligent control systems, as well as their practical realization using Matlab/Simulink and different plants within a modular educational real-time control system (inverted pendulum, double inverted pendulum, 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.

• Intelligent Control Systems Laboratory.

lecture hours of active teaching: 35

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

Simon Haykin, "Neural Networks and Learning Machines", Vol. 3. Upper Saddle River, NJ, USA:: Pearson, 2009.

Ethem Alpaydin, "Introduction to machine learning", 2nd Edition, The MIT Press, Cambridge, England, 2010.

W. Thomas Miller, Richard S. Sutton, Paul J. Werbos, "Neural networks for control", The MIT Press, Cambridge, MA, USA, 1995.

Advanced linear systems

ID: PhD-3410
responsible/holder professor: Ristanović R. Milan
teaching professor/s: Ristanović R. Milan
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
• Frazzoli, Emilio, and Munther Dahleh. 6.241J Dynamic Systems and Control, Spring 2011. (MIT OpenCourseWare: Massachusetts Institute of Technology), http://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-241j-dynamic-systems-and-control-spring-2011 (Accessed 30 Aug, 2013). License: Creative Commons BY-NC-SA
• 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.
lecture hours of active teaching: 35

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

Luenberger, David. Introduction to Dynamic Systems: Theory, Models, and Applications. Wiley, 1979. ISBN: 9780471025948.
Kailath, Thomas. Linear Systems. Prentice Hall, 1980. ISBN: 9780135369616.
Doyle, John, Bruce Francis, and Allen Tannenbaum. Feedback Control Theory. Dover, 2009. ISBN: 9780486469331.
Vaccaro, Richard. Digital Control: A State-Space Approach. McGraw-Hill, 1995. ISBN: 9780070667815.
Sigurd Skogestad, Ian Postlethwaite: Multivariable Feedback Control: Analysis and Design, 2nd Edition, 2005. ISBN: 978-0-470-01168-3

Advanced Manufacturing Systems

ID: PhD-3364
responsible/holder professor: Miljković Đ. Zoran
teaching professor/s: Miljković Đ. Zoran
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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

lecture hours of active teaching: 35

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 MOBILE ROBOTS, 2nd Edition, The MIT Press; R.Siegwart,I.R.Nourbakhsh, (2004) INTR. TO AUTONOMOUS MOBILE ROBOTS, The MIT Press.
R. R. Murphy, (2000) INTRODUCTION TO AI ROBOTICS, A Bradford Book, The MIT Press, Cambridge, Massachusetts, London, England.
M.P. Groover, (2001) AUTOMATION, PRODUCTION SYSTEMS, AND COMPUTER-INTEGRATED MANUFACTURING, 2nd Edition, Prentice Hall.
W. Van de Velde (editor), (1993) TOWARD LEARNING ROBOTS, MIT Press, Special Issues of Robotics and Autonomous Systems, 1993.

Advanced Methods for Maintenance of Railway Vehicles

ID: PhD-3139
responsible/holder professor: Lučanin J. Vojkan
teaching professor/s: Lučanin J. Vojkan, Tanasković D. Jovan
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Systems approach to the maintenance of rail vehicles. Maintenance and life cycle. Maintenance process. Maintenance systems. Systems maintenance of rail vehicles(maintenance Serbian Railway, applied systems of maintenance of railway vehicles in the world). Integrated logistics and technical security of rail vehicles. Analysis and evaluation of system maintenance. Management of spare parts. Information systems maintenance.

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).

lecture hours of active teaching: 35

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

S. Muzdeka, Logistics, Script, Institute of Nuclear Science "Boris Kidric", Vinca, 1981.
N. Vujanovic, Theory of reliability of technical systems, Belgrade, 1990.
J. Todorovic, Engineering of maintenance of technical systems , JUMB, Belgrade, 1993.

Advanced Nuclear Reactors

ID: PhD-3527
responsible/holder professor: Stevanović D. Vladimir
teaching professor/s: Stevanović D. Vladimir
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
An overview of nuclear reactor operational principles. Methods of nuclear reactor thermal-hydraulic design. Study and analyses of generation III, III+ and generation IV reactors.

Features and merits of small modular reactors.

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.

lecture hours of active teaching: 35

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
D. Bodansky, Nuclear Energy, Principles, Practises, and Prospects, Springer, 2004.
Tong, L.S., Principles of Design Improvements for Light Water Reactors, Hemisphere, 1988.

Saha, P., Issues and future direction of thermal-hydraulics research and development in nuclear power reactors, Nuclear Engineering and Design, 264 (2013), pp. 3-23.
Klimov, A., Nuclear Physics and Nuclear Reactors, Mir Publishers, Moscow, 1981.
Knief, R.A., Nuclear Energy Technology, Hemisphere, 1981.

Advanced Numerical Methods

ID: PhD-3555
responsible/holder professor: Svorcan M. Jelena
teaching professor/s: Svorcan M. Jelena
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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.

lecture hours of active teaching: 35

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
Anderson J.D.Jr., Computational Fluid Dynamics - The Basics with Applications, McGraw-Hill, New York, 1995.
Ferziger J.H., Perić M., Computational Methods for Fluid Dynamics, Springer-Verlag, Berlin Heidelberg, 2002.

Mathews J.H, Fink K.D, Numerical Methods using MATLAB, Prentice Hall, Upper Saddle River,1999.
Press W.H, Teukolsky S.A, Vetterling W.T, Flannery B.P, Numerical Recipes in Fortran 77 - The Art of Scientific Computing, Cambridge University Press, Cambridge, 1997.
Additional materials

Advanced robotics-selected chapters

ID: PhD-3127
responsible/holder professor: Lazarević P. Mihailo
teaching professor/s: Lazarević P. Mihailo
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Basic concepts and specifications of advanced robotic system (RS). Rodriguez formula and the transformation matrix (MT). Determining of kinematic parameters of RS. Direct and inverse kinematics of robot task- characteristic cases. Fundamentals of quaternion theory and theory of finite rotations.

Differential equations (DIFE)of motion of RS applying Rodrigues approach and quaternions: typical cases-in the form of kinematic chain with the structure of topological three,in the form of closed-kinematic chain. Equations of motion of RS with Langrange multipliers. Kane's equations of motions of RS.Redundant RS. Fundamentals of advanced control algorithms of RS as well as remote control RS. Applications of control of RS based on fractional calculus. Fundamentals of robot programming languages.

Solving typical tasks of advanced robotic systems: resolving redundant problem,obstacle avoidance,task planning and navigation,robot vision. A example of biologically inspired intelligent robot.

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 RS.Simulation 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)

3.Wittenburg J., Dynamics of Systems of Rigid Bodies, Teubner, Stuttgart, 1977. (XJ)

4.Craig J., Introduction to Robotics, Mechanics and Control, Addison-Wesley, 1989.

5.Written abstracts from the lectures (Handouts)

6.Cyberbotics Webots - software package

7.NeuroArm-laboratory robot with 7 degrees of freedom.

8.MATLAB,MATHEMATICA-mathematics software packages

9.Kuipers, J.B.: Quaternions and Rotation Sequences: A Primer with Applications to Orbits,Aerospace and Virtual Reality, Princeton University Press, New Jersey, 1999.

10. Craig Sayers,Remote Control Robotics,Springer,1998.

11.C. A. Monje, YQ. Chen, B. M. Vinagre, D. Xue, V. Feliu, Fractiona Order Systems and Controls – Fundamentals and Applications, Springer, 2010

lecture hours of active teaching: 35

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

Bruno Siciliano, Oussama Khatib, Springer Handbook of Robotics,Springer-Verlag Berlin Heidelberg 2008.
Thomas R. Kurfess.,Robotics and automation handbook,CRC Press LLC, Boca Raton, Florida,2005
Ahmed A. Shabana, Dynamics of Multibody Systems,Cambridge University Press The Edinburgh Building, Cambridge , UK,2005.
M.W. Spong, M. Vidyasagar: Robot Dynamics and Control (Wiley, New York 1989)
Yoseph Bar-Cohen, Cynthia L. Breazea,Biologically Inspired Intelligent Robots ,SPIE org,2003

Advanced Systems in Intelligent Buildings

ID: PhD-3413
responsible/holder professor: Ristanović R. Milan
teaching professor/s: Ristanović R. Milan
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
The definition of intelligent buildings. Technological systems in intelligent buildings. Introduction to digital control systems: analog / digital input / output values, sensors, actuators, digital controllers. Basic communication standards and their characteristics. Control algorithms and tuning.

Management of central heating systems. Control of boilers. Control of substations. Outdoor temperature compensation. Central and zone control. Control in the solar system. Managing in the air conditioning. Typical control schemes of air conditioning. Cascade control. Secvential control. Regulation of air humidification. Control of air handling unit with variable flow. Lighting control systems. Lighting control system components, analog / digital control and lighting control strategies. Protection systems and solar radiation and control strategies. Measuring energy consumption. Fire protection systems. Access control systems. Building management systems. Application of Internet technology in control.

practical teaching
Understanding the physical implementation of sensors, digital controllers and drivers. Understanding the physical implementation of control systems in buildings. Programming and networking of digital controllers. Realization of 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
lecture hours of active teaching: 35

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

Maja Todorovic, M. Ristanovic, Efficient Energy Use in Buildings, University of Belgrade, 2015, ISBN 978-86-7083-875-8
Shengwei Wang, Intelligent Buildings and Building Automation, Spon Press, New York, 2010
H. Merz, T. Hansemann, C. Huebner, Building Automation, Springer-Verlag, Berlin Heidelberg, 2009
C.F. Mueller, Regelungs- und Steuerungstechnik in der Versorgungstechnik, 2002

Advanced techniques in IC Engine testing

ID: PhD-3422
responsible/holder professor: Miljić L. Nenad
teaching professor/s: Miljić L. Nenad
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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 analisys, emmision 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 instantenous 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 equiped Engine test lab with AC dynamometer and Automation System.

Digital Acquisistion system based on National Instruments Hardware and Software.

AVL Indimodul

lecture hours of active teaching: 35

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

Plint, M., Martyr, A.: Engine testing - Theory and practice, Butterworth-Heinemann, Oxford, 1997. ISBN 0-7506-1668-7.

Advanced Thermal Power Cycles

ID: PhD-3209
responsible/holder professor: Petrović V. Milan
teaching professor/s: Petrović V. Milan
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Steam turbines cycles. Cycles with ultra super critical parameters. Complex steam turbine cycles. Advance gas turbine cycles. Complex gas turbine cycles. Cycles with turbine cooling. Combined gas turbine/steam turbine cycles. Cycle optimization. Parameters selection. Cycle configuration selection. Cost/benefit analysis of thermal power plant. Energy and exergy analysis. Optimization of power plant operation.

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

lecture hours of active teaching: 35

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

Petrovic, M.: Steam turbines, script, 2004.
Stojanovic, Themal Turbomachinery, Gradjevinska knjiga, Belgrade, 1967.
A.Bejan, G. Tsatsaronis, M. Moran: Thermal Design and Optimization, Wiley, 1996.
Traupel,W.: Thermische Turbomaschinen, Springer verlag, Berlin, 1982
Cohen, H., Rogers,G.F.C., Saravanamuttoo, H.I.H.: Gas turbine theory, Logman, 1997.

Advanced topics in warhead design

ID: PhD-3600
responsible/holder professor: Elek M. Predrag
teaching professor/s: Elek M. Predrag
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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.

Material behavior. Penetration modeling. Explosive propulsion - application to HE fragmentation warhead. Shaped charge mechanism.

prerequisite
No.

learning resources
1. Jaramaz, S.: Warhead design and terminal ballistics, Faculty of Mechanical Engineering, Belgrade, 2000.

2. Lloyd, R.M.: Conventional Warhead Systems Physics and Engineering Design, Progress in Astronautics and Aeronautics, Volume 79, AIAA, 1998.

lecture hours of active teaching: 35

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

-

Advanced Topics of Missile Guidance

ID: PhD-3509
responsible/holder professor: Todić N. Ivana
teaching professor/s: Todić N. Ivana
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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:

Presentation and comparison of basic guidance laws (proportional navigation, constant bearing and line-of-sight guidance) in terms of principal information required for realization and demands for guidance. Midcourse and terminal guidance. Basic components of missile. The application of gimbaled and strapdown seeker during terminal guidance. Comparison of classical and modern guidance and control. Definition of Lambert's problem in flight mechanics of guided weapons. Optimal guidance based on linear-quadratic differential games. Mathematical background for noise analysis. Digital fading memory noise filters in homing loops. Estimation theory applied to guidance loop. Other forms of tactical guidance. Basic flight mechanics for tactical and strategic missile. Lambert guidance. Guidance technique and numerical examples for solving Lambert guidance. Modifications of Lambert.

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

prerequisite
None

learning resources
P. Garnel: Guided Weapon Control System, Pergamon Press, New York, 1980.

lecture hours of active teaching: 35

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
Siouris, G.M., “Missile Guidance and Control Systems”, Springer, ISBN 0-387-00726-1, 2004
Boiffier, J.L., “The Dynamic of Flight The Equations”, John Wiley & Sons Ltd. England, ISBN 0-471-94237-5, 1998

Titterton, D.H. and Weston, J.L., ”Strapdown Inertial Navigation Technology – 2nd edition”, 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 and Position Algorithms”, Journal of Guidance, Control, and Dynamics, Vol. 21, No. 2, pp. 208-221
Landau, I.D., Lozano, R., M’Saad, M., Karimi, A., “Adaptive Control Algorithms, Analysis and Applications”, Springer, ISBN 978-0-85729-663-4, 2011

Aerodynamic Shape Optimization

ID: PhD-3015
responsible/holder professor: Bengin Č. Aleksandar
teaching professor/s: Bengin Č. Aleksandar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Knowlege of basic CFD and of C/C++ or FORTRAN languages is preferable.

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

lecture hours of active teaching: 35

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 and Flight Mechanics for Autopilot and Guidance System Design

ID: PhD-3508
responsible/holder professor: Todić N. Ivana
teaching professor/s: Todić N. Ivana
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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.

Input data for the autopilot and guidance system design.Equations of motion.Programmed flight in vertical plane and reference trajectories. Linearization of the equations of motion and missile transfer functions. Missile instruments and actuator used by autopilot.Lateral autopilot requirements and objectives.Design of pitch autopilot with rate gyro and accelerometer. Design of the pitch autopilot for the statically unstable missile.Roll autopilot design. Autopilot Design using Feedback Linearization Method.

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)

lecture hours of active teaching: 35

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

P. Garnel: Guided Weapon Control System, Pergamon Press, New York, 1980.
Danilo Ćuk: Design of Beam-Riding Laser Guidance System,MTI, 1998. (skripte na engleskom)
Danilo Ćuk: Theory of Homing Systems, Proportional Navigation,MTI, 1998. (skripte na engleskom)

Aerodynamics of Thermal Turbomachinery

ID: PhD-3210
responsible/holder professor: Petrović V. Milan
teaching professor/s: Petrović V. Milan
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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.Experimanthal methods for mesuremets 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.

lecture hours of active teaching: 35

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

Petrovic, M.: Berechnung der Meridionalströmung in mehrstufigen Axialturbinen bei Nenn- und Teillastbetrieb, VDI-Verlag GmbH, Düsseldorf, 1995, 124 Seiten, ISBN 3-18-328007-8
Stojanovic, Themal Turbomachinery, Gradjevinska knjiga, Belgrade, 1967.
Traupel,W.: Thermische Turbomaschinen, Springer verlag, Berlin, 1982
Cumpsty, N.A , Compressor Aerodynamics, 1989 Longman Scientific and Technical, 2004 Krieger, 2004
Lakshninarajana, B: Fluid Dynamics and Heat Transfer of Turbomachinery, Wiley, 1996,

Aerodynamics of Turbocompressors

ID: PhD-3369
responsible/holder professor: Petrović V. Milan
teaching professor/s: Petrović V. Milan
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Thermodynamic background of turbocompressors.Processes turbocompressors. Efficiency. Cascades of turbocompressors. Geometric and operating parameters of the cascades. Main aerodynamic cascade parameters. Aerodynamic losses of compressor stages. Deviation model. Mean-line theory of compressor stages. Energy balance of the compressor stage. Design factors of turbocompressors. Dependence of the compression ratio from the operating parameters. 3D flow in normal stages of axial compressors. Optimal design factors. Determination of main dimensions of axial compressors. The behavior of the compressors at variable loads.

practical teaching
Development of methodology and software for aerdynamic design of compressors.

prerequisite
PhD- student -thermal power enegineering

learning resources
Computing facility,literature

lecture hours of active teaching: 35

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

Petrovic, M: gas turbines and Turbocompressors, scrip, 2004.
Stojanovic, Themal Turbomachinery, Gradjevinska knjiga, Belgrade, 1967.
Traupel,W.: Thermische Turbomaschinen, Springer verlag, Berlin, 1982
Cumpsty, N.A , Compressor Aerodynamics, 1989 Longman Scientific and Technical, 2004 Krieger, 2004
Lakshninarajana, B: Fluid Dynamics and Heat Transfer of Turbomachinery, Wiley, 1996,

Aero-hydrodynamics of Sailing Yachts

ID: PhD-3486
responsible/holder professor: Kalajdžić D. Milan
teaching professor/s: Kalajdžić D. Milan
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Introduction to sailing. Basic terminology related to the boat. Types of sails and sail coefficients. Basic Aerodynamics of sailing yacht. Basics hydrodynamics of sailing yacht. The interaction of aero-hydrodynamic forces and moments. Equilibrium and determination the speed of the sailing yacht (Velocity prediction program - VPP). Modeling of gust wind. Deriving and solving differential equations of sailing yacht motion in gusting wind.

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.

lecture hours of active teaching: 35

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

L. Larssen and R. Eliasson, "Principles of Yacht Design", McGraw Hill, 2000
C.A. Marchaj, "Aero-Hydrodynamics of Sailing", Tiller Pub. 2000
F. Fossati, “Aero-hydrodynamics and the Performance of Sailing Yachts: The Science Behind Sailing Yachts and Their Design”, Adlard Cole Nautical, 2009

Aeronautical Maintenance and Support

ID: PhD-3448
responsible/holder professor: Bengin Č. Aleksandar
teaching professor/s: Bengin Č. Aleksandar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
The modern concept of aeronautical maintenance and support in the world today. Quantitative indicators of reliability and maintainability of aircraft systems. Maintainability prediction methods aviation system. Combat aircraft survivability. Increasing of the combat aircraft survivability. Sensitivity to aircraft damage. Vulnerability of aircraft. Identification of critical components. Levels of destruction of aircraft. Concepts to reduce vulnerability of aircraft.

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.

lecture hours of active teaching: 35

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

R. Ball, Fundamentals of Aircraft Combat Survivability: Analysis and Design, 2nd Edition,
Alessandro Birolin, Reliability Engineering: Theory and Practice, Springer Verlag, 2007.

Aircraft Flight Dynamics

ID: PhD-3443
responsible/holder professor: Bengin Č. Aleksandar
teaching professor/s: Bengin Č. Aleksandar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
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. Aerodynamic stability derivatives of aircraft. Systems of equations of generalized stability and control of aircraft and missile systems. Inverse Problems of Stability. Flight in a turbulent atmosphere.

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
Robert F. Stengel, Flight Dynamics, Princeton Univ. Pr., 2004., Michael V. Cook, Flight Dynamic Principles: A Linear Systems Approach to Aircraft Stability and Control,Butterworth-Heinemann, Oxford, 2007 and Ashish Tewari, Atmospheric and Space Flight Dynamics: Modeling and Simulation with MATLAB and Simulink, Birkhauser, 2006, include necessary material for lectures, exercises, assignments, projects and term papers.

Required 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.

lecture hours of active teaching: 35

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
responsible/holder professor: Bengin Č. Aleksandar
teaching professor/s: Bengin Č. Aleksandar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Modern Aluminium, Nickel, Titanium and Beryllium alloys. Modern composite materials.

Thermoplastic and thermoset materials in aviation. Synthetic resins - matrix (binder) materials: epoxy, polyester, vinyl ester-, phenolic, polyimide, etc. bizmaleimidne. Armirajuća fibers: glass, carbon, aramid and pine (Kevlar). Prepreg materials. Modern hybrreinforced. Reinforced materials. Composites based metal matrix. Modern ceramic materials. "Smart" and functional materials in modern aeronautical engineering. Piezoelectric materials, alloys with the possibility of "saving" shape. Intelligent composite actuators. Cellular materials, intelligent

optical fibers. Electric, magnetic and semiconductor materials.

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.

lecture hours of active teaching: 35

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
responsible/holder professor: Kostić A. Ivan
teaching professor/s: Kostić A. Ivan, Kostić P. Olivera
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Historical perspective. Design characteristics and notation of airfoil families. Aerodynamic characteristics. Drag coefficient components. Influence of viscosity. Laminar airfoils. Compressibility effects (subcritical and supercritical flow). Supercritical airfoils. Supersonic airfoils. Experimental techniques (methods of pressures and forces, energy methods and optical methods). Theoretical modeling of airfoils (singularity methods, thin airfoil theory, droplet method, conformal mapping).

Types and basic characteristics of lifting surfaces. Planar and non-planar lifting surfaces. The "C" wing and ring wing. Grid lifting surfaces. Mathematical model of flow around lifting surfaces. Vortex line theory. Lifting surface methods. Biplane theory. Wing tip optimization, winglets. Source and sink methods in lifting surface calculations. Small disturbance methods. Method of characteristics. Conical flow fields. Swept wing in transonic and supersonic flow. Leading edge types. Wing-fuselage interference, wing leading edge extensions (strake). Delta wings. Airfoil and wing control surfaces (ailerons, flaps, slots, tabs and spoilers).

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.

lecture hours of active teaching: 35

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 Engineeering, Belgrade, 2014.
R.T.Jones & D.Cohen: High Speed Wing Theory, Princeton University Press, 1980.
I. Kroo: Nonplanar Wing Concepts for Increased Aircraft Efficiency, von Karman Institute lecture series on Innovative Configurations and Advanced Concepts for Future Civil Aircraft, 2005.
J. Katz, A. Plotkin: Low Speed Aerodynamics from Wing Theory to Panel Method, McGraw-Hill Co., Singapore, 1991.
Different NASA и AIAA technical reports and papers

Alternative vehicle drives

ID: PhD-3567
responsible/holder professor: Blagojević A. Ivan
teaching professor/s: Blagojević A. Ivan
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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 overcame. 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
lecture hours of active teaching: 35

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
responsible/holder professor: Jeremić M. Olivera
teaching professor/s: Jeremić M. Olivera
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Free and constrained mechanical system. Contraints and their classification. Introductory treatise of generalized coordinates. Quasi-velocities and quasi-coordinates. Possible and virtual displacements. Ideally smooth constraints. Differential principles of mechanics and their application in differential equations forming. Lagrange's equations of first and second kind. Energy integral. Cyclic coordinates and cyclic integral. Routh's equations. Function of acceleration and Appell's equations. Integral principles. First and second form of Hamilton's principle. Canonical equations. Lagrange's principle of steady action. Geometrical interpretation of particle's and mechanical system's motion. Hertz's principle of the least curvature.

practical teaching
Free and constrained mechanical system. Contraints and their classification. Introductory treatise of generalized coordinates. Quasi-velocities and quasi-coordinates. Possible and virtual displacements. Ideally smooth constraints. Differential principles of mechanics and their application in differential equations forming. Lagrange's equations of first and second kind. Energy integral. Cyclic coordinates and cyclic integral. Routh's equations. Function of acceleration and Appell's equations. Integral principles. First and second form of Hamilton's principle. Canonical equations. Lagrange's principle of steady action. Geometrical interpretation of particle's and mechanical system's motion. Hertz's principle of the least curvature.

prerequisite
Defined by the curriculum study of Phd studies program.

learning resources

[1] Andjelic T., Stojanovic R.; Rational Mechanics, Belgrade, 1966.

[2] Lurje A.; Analytical Mechanics, Moscow, 1961.

[3] Gantmaher F.; Lessons on Analytical Mechanics, Nauka, Moscow, 1966.

lecture hours of active teaching: 35

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

Anđelić T.; Stojanović R.; Racionalna mehanika, Zavod za izdavanje udžbenika SRS, Beograd, 1966.
Lurje A.; Analitičeskaja mehanika, Moskva, 1961.
Gantmaher F.; Lekciji po analitičeskoj mehanike, Nauka, Moskva, 1966.

Analytic Methods for Engineering Design

ID: PhD-3341
responsible/holder professor: Babić R. Bojan
teaching professor/s: Babić R. Bojan
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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

lecture hours of active teaching: 35

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
N. P. Suh, (1990) THE PRINCIPLES OF DESIGN, Oxford University Press, New York
G. J. Park, (2007) ANALYTIC METHODS FOR DESIGN PRACTICE, Springer Verlag, London

Analytical methods for engineering design

ID: PhD-3012
responsible/holder professor: Babić R. Bojan
teaching professor/s: Babić R. Bojan
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Examples of application of analytic design methods. Axiomatic design of products, processes and systems. Application of axiomatic design in manufacturing domain. Defining functional requirements for manufacturing system. Design for manufacturing, design of manufacturing processes and intelligent machines. Intelligent system for design of manufacturing systems. Project and consultations about project. Software packages for axiomatic design. Examples of making designs based on ergonomics. Discussions and workshops.

prerequisite
Defined by curriculum of study programme/module.

learning resources

(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

lecture hours of active teaching: 35

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
N. P. Suh, (1990) THE PRINCIPLES OF DESIGN, Oxford University Press, New York
G. J. Park, (2007) ANALYTIC METHODS FOR DESIGN PRACTICE, Springer Verlag, London

Anisotropic plates and shells

ID: PhD-3013
responsible/holder professor: Balać M. Igor
teaching professor/s: Balać M. Igor, Milovančević Đ. Milorad
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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 of 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.

2. Macro mechanical elastic behavior of unidirectional lamina composites. The Hooke's Law for a two dimensional lamina. Determining stiffness of parallel arrays of fibers in matrix. Rules of mixture. Off-axis properties of a lamina.

3. Determining strength of unidirectional lamina. Analysis of failure criteria. Diverse failure criteria and their applications.

4. Macro mechanical elastic behavior of multidirectional othotropic laminates. Stress and strain analysis of single lamina, and of the entire orthotropic material. General laminate plate theory. Studding of coupling effects – coupled flexure and torsion.

5. Stress – strain and failure analysis of multidirectional othotropic materials. Strength of lamina under tension and shear. Inter-laminar stresses. Laminate strength analysis. First ply failure.

practical teaching

1. Analytical examples of the assessment of macro mechanical properties of the 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.

3. Numerical exercises of stress strain analysis of orthotropic laminate. Examples of determination of local and global values for stress and strain.

4. Numerical examples of determination of the ultimate strength using diverse failure criteria. Practical applications of failure theory to the ultimate strength calculations of mechanical components made out of 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 strenght 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.

lecture hours of active teaching: 35

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-3610
responsible/holder professor: Bakić M. Gordana
teaching professor/s: Bakić M. Gordana, Sedmak S. Aleksandar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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 analized. The potential co-operation 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 structurs 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 able to link their knowledge in this field with other areas and apply them in practice.

theoretical teaching

Application of fracture mechanics to structural integrity assessment.Initiation of a crack in a weldment. The possibility of using fracture mechanics criteria to assess safety of welded joints. Mechanical structures integrity considering fracture toughness. Damage mechanics and its application to ductile fracture. Estimates in the domain of elasticity and elasto-plasticity. Residual strength assessment of pressure vessels with surface errors using the resistance curves. Crack growth force in relation to the tensile engineering materials curves. Fracture mechanics analysis and allowed defect size curves for surface cracks in pipes. Fatigue surface crack growth in welded joints. Determination of fracture mechanics parametars with thermo mechanical load. J integral as the law of conservation. Direct measurement of the J integral. Local access.

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. The application of elastic-plastic fracture mechanics. CTOD design curve. Failure Assessment Diagrams. PD6493 procedures. R6 method. J-integral analysis of crack growth. Structural integrity assessment using acquired knowledge. Directly measuring the J integral - Reed's original work. Examples of modifications - the strength and heterogeneity of material. An example of two-dimensional stress analysis - pressure vessels. Assessment of properties of welded joints using standard cracked specimens. Consultation.

prerequisite

-

learning resources

[1] Written lessons from lectures (handouts)

[2] A. Sedmak, Use of the fracture mechanics on the structure integrity assessment, Faculty of Mechanical Engineering, Belgrade, 2003.

[3] T.L. Anderson, Fracture Mechanics: Fundamentals and Applications, 3rd ed, CRC Press, London, 2005.

[4] G Jovicic., Zivkovic M., S Vulović., Computational fracture mechanics and fatigue, Faculty of Mechanical Engineering, Kragujevac, 2011.

[5] Marko. P. Rakin, Local access to a ductile fracture of metallic materials. TMF, Belgrade, 2009.

[6] S. Sedmak, A. Sedmak, Experimental and numerical methods of fracture mechanics in structural integrity assesment, TMF, Belgrade, 2000.

[7] Excerpts from the standard

lecture hours of active teaching: 35

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

T.L. Anderson, Fracture Mechanics: Fundamentals and Applications 3rd ed. CRC Press, London, 2005.
Jin Z. H., Sun C.T., Fracture Mechanics, Academic Press, 2011.
G. Pluvinage, Fracture and Fatigue Emanating from Stress Concentrators, Springer, Dordrecht, 2004.
A. Sedmak, S. Sedmak, LJ. Milović, Pressure eljuipment inegrity assessment bz elastic-plastic fracture mechanics methods, monografija, DIVK, Beograd, 2011.
Broek D., The Practical Use of Fracture Mechanics, Springer, 1989.

Artificial Intelligence & Machine Learning

ID: PhD-3353
responsible/holder professor: Miljković Đ. Zoran
teaching professor/s: Miljković Đ. Zoran
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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

[3] Z. Miljković, Software "Moodle" for distance learning (http://147.91.26.15/moodle/), University of Belgrade, Faculty of Mechanical Engineering, 2012, 18.13

lecture hours of active teaching: 35

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
S.J. Russel, P. Norving, (2003-2nd ed., 1995-1st ed.) ARTIFICIAL INTELLIGENCE – A MODERN APPROACH, Prentice Hall.
E. Alpaydin, (2010-2nd ed., 2004-1st ed.) INTRODUCTION TO MACHINE LEARNING, The MIT Press, Cambridge, England.
R. R. Murphy, (2000) INTRODUCTION TO AI ROBOTICS, A Bradford Book, The MIT Press, Cambridge, Massachusetts, London, England.
R.M. Golden, (1996) MATHEMATICAL METHODS FOR NEURAL NETWORK ANALYSIS AND DESIGN, MIT Press.
R.S. Sutton, A.G. Barto, (1998) REINFORCEMENT LEARNING: AN INTRODUCTION, MIT Press.

Artificial Intelligence of Motor Vehicles

ID: PhD-3000
responsible/holder professor: Aleksendrić S. Dragan
teaching professor/s: Aleksendrić S. Dragan
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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., Carlone P. Soft computing in the Design and Manufacturing of Composite Materials, Elsevier, 2015.

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

Miljković Z., Aleksendrić D. Veštačke neuronske mreže - zbirka rešenih zadataka sa izvodima iz teorije, Mašinski fakultet Beograd, 2009.

Savaresi S., Taneli M. Active Braking Control Systems Design for Vehicles, Springer 2010.

Li L., Wang F.Y. Advanced Motion Control and Sensing for Intelligent Vehicles, Springer, 2007.

Bishop R. Intelligent Vehicles Technology and Trends, Artech House INC, 2005.

Vachtsevanos G., Lewis F.L.,Roemer M., Hess A., Wu B. Intelligent Fault Diagnosis and Prognosis for Engineering Systems,John Wiley&Sons INC,2006.

Mas F.R., Zhang Q., Hansen A. Mechatronics and Intelligent Systems for Off-Road Vehicles, Springer, 2010.

lecture hours of active teaching: 35

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
responsible/holder professor: Miljković Đ. Zoran
teaching professor/s: Miljković Đ. Zoran
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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);
• Trends of development of autonomous robots - Micro- nano-robots; Potential risks of intensive development of autonomous robots.

practical teaching
Practical education is organized in several parts:

• Localization and mapping of the manufacturing environment - introduction to SLAM (laboratory work);

• Communicative and interactive competence of robots in working environment (laboratory work);

• Machine learning in accordance with intelligent 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, M.M. Petrović, INTELLIGENT MANUFACTURING SYSTEMS – with excerpts from robotics and artificial intelligence (1st ed.), Textbook, XXVIII+409 p., University of Belgrade - Faculty of Mechanical Engineering, 2021, 18.1 /In Serbian/

[2] 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] M. Kalajdžić (editor), Lj. Tanović, B. Babić, M. Glavonjić, Z. Miljković, et al., CUTTING TECHNOLOGY (8th ed.), Handbook, University of Belgrade - Faculty of Mechanical Engineering, 2017, 18.1 /In Serbian/

[4] Z. Miljković, Systems of artificial neural networks in production technologies, Monograph book within the Series Intelligent Manufacturing Systems, Vol. 8, University of Belgrade - Faculty of Mechanical Engineering, 2003, 18.1 /In Serbian/

[5] B. Babić, FLEXY - Intelligent system for FMS design, Monograph book within the Series Intelligent Manufacturing Systems, Vol. 5, University of Belgrade - Faculty of Mechanical Engineering, 1994, 18.1 /In Serbian/

[6] 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

[7] Laboratory model of designed manufacturing system, Laboratory CeNT, University of Belgrade - Faculty of Mechanical Engineering, 18.12

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

lecture hours of active teaching: 35

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
Z.Miljković, D.Aleksendrić, ARTIFICIAL NEURAL NETWORKS–SOLVED EXAMPLES WITH THEORETICAL BACKGROUND (in Serbian),2nd Edition. University of Belgrade–Faculty of Mechanical Engineering, Belgrade, (2018).

R.Siegwart,I.R.Nourbakhsh,D.Scaramuzza, INTRODUCTION TO AUTONOMOUS MOBILE ROBOTS, 2nd Edition, The MIT Press, (2011); R.Siegwart,I.R.Nourbakhsh, INTR. TO AUTONOMOUS MOBILE ROBOTS, The MIT Press, 2004.
G.A. Bekey, AUTONOMOUS ROBOTS: From Biological Inspiration to Implementation and Control, The MIT Press, Cambridge, Massachusetts, London, England, (2005) .
R.A. Brown, MACHINES THAT LEARN, Oxford University Press, (1994).
E. Alpaydin, INTRODUCTION TO MACHINE LEARNING, 2nd Edition, The MIT Press, Cambridge, England, (2010).; E. Alpaydin, INTRODUCTION TO MACHINE LEARNING, The MIT Press, Cambridge, England, (2004).

Basic Principles of Fracture Mechanics

ID: PhD-3608
responsible/holder professor: Radaković J. Zoran
teaching professor/s: Radaković J. Zoran, Sedmak S. Aleksandar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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 elsatoplastic 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
Basic assumptions of elastic-plastic fracture mechanics of materials. Main subject of investigation in fracture mechanics. Classification of fractures. Fracture mechanics parameters of engineering materials. Stress field at the crack tip. Analysis of the brittle fracture problem. Stress intensity factor. Fracture toughness- critical value for stress intensity factor.Crack tip opening. J - contour integral. J integral as a parameter for stress and deformation fields. Nonlinear energy release rate. The connection between the J integral and CTOD. The zone of final stretch. Local access to metallic materials fracture. Local approach in the analysis of crack formation and ductile fracture.

Analytical determination of stress intensity factors. Analytical determination of the crack opening and the J integral . REI model. King's model. Experimental determination of fracture mechanics parameters. Numerical determination of fracture mechanics parameters. Finite element fracture analysis.

practical teaching
Application of fracture mechanics standards. The application of the J integral on crack growth analysis. Empirical formula for the CTOD. EFAM ETM97. EPRI engineering procedures. Experimental determination of fracture mechanics parameters. Determination of fracture toughness. Determination of the critical crack tip opening. Experimental determination of J integral - standard procedure. Measuring the strength of the final zone.

Experimental methods for determining the microstructural properties of metallic materials. Numerical methods for determining fracture mechanics parameters. Recommendations of the European Association for Structural Integrity (ESIS).

prerequisite
-

learning resources
1] Written lessons from lectures (handouts)

[2] A. Sedmak, Use of the fracture mechanics on the structure integrity assessment, Faculty of Mechanical Engineering, Belgrade, 2003.

[3] T.L. Anderson, Fracture Mechanics: Fundamentals and Applications, 3rd ed, CRC Press, London, 2005.

[4] G Jovicic., Zivkovic M., S Vulović., Computational fracture mechanics and fatigue, Faculty of Mechanical Engineering, Kragujevac, 2011.

[5] Mark. P. Rakin, Local access to a ductile fracture of metallic materials. TMF, Belgrade, 2009.

lecture hours of active teaching: 35

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
T.L. Anderson, Fracture Mechanics: Fundamentals and Applications 3rd ed. CRC Press, London, 2005.
Jin Z. H., Sun C.T., Fracture Mechanics, Academic Press, 2011.
G. Pluvinage, Fracture and Fatigue Emanating from Stress Concentrators, Springer, Dordrecht, 2004.
J. N. Reddy, An Introduction to the Finite Element Method (Engineering Series), 2005.
Roger T. Fenner, Finite Element Methods for Engineers, 1997.

Biofluid mechanics – advanced course

ID: PhD-3266
responsible/holder professor: Stevanović D. Nevena
teaching professor/s: Lečić R. Milan, Stevanović D. Nevena
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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 haemodialys process and renal flow.

prerequisite
Passed exams in Fluid Mechanics.

learning resources
Course handouts.

lecture hours of active teaching: 35

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

Waite L., Fine J., Applied Biofluid Mechanics, MsGraw-Hill, 2007.
Mazumdar, N.J., Biofluid Mechanics, World Scientific, 1992.
Kleinstreuer, C., Biofluid Dynamics, Principles and Selected Applications, Taylor & Francis, 2006.
Fung, Y.C., Biomechanics Motion, Flow, Stress and Growth, Springer-Verlag, 1990.

Biologically Inspired Optimization Algorithms

ID: PhD-3529
responsible/holder professor: Petrović M. Milica
teaching professor/s: Petrović M. Milica
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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 with the objective 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-world optimization problems.

theoretical teaching

Introduction to biologically inspired optimization algorithms. Discrete and continuous optimization problems. Combinatorial optimization problems. NP-hard problems. Stochastic optimization. Single-objective and multi-objective optimization. Review of optimization algorithms. Simulated Annealing. Tabu Search algorithm (TS). Evolutionary metaheuristic algorithm: Genetic Algorithms (GA), Evolutionary Programming (EP), Evolution Strategy (ES), Genetic Programming (GP). Swarm Intelligence: Particle Swarm Optimization (PSO), Ant Colony Optimization (ACO), Ant Lion Optimizer (ALO), Bee Colony Optimization (BCO), Firefly Algorithm (FA), Fruit fly Optimization Algorithm (FOA), Grey Wolf Optimizer (GWO), Whale Optimization Algorithm (WOA), etc. Hybrid metaheuristic algorithms. Chaos theory and optimization algorithms. The basic concepts of biologically inspired optimization algorithms, solution coding/decoding procedures, operators, parameters settings, and parameters tuning. The performance of optimization algorithms. Comparison of optimization algorithms.

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&AI), Department of Production Engineering, University of Belgrade - Faculty of Mechanical Engineering. MATLAB software.

lecture hours of active teaching: 35

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

Engelbrecht, A.P. (2007). Computational intelligence: an introduction. John Wiley & Sons
Talbi, E.G. (2009). Metaheuristics: from design to implementation (Vol. 74). John Wiley & Sons
Wahde, M. (2008). Biologically inspired optimization methods: an introduction. WIT press
Yu, X., Gen, M. (2010). Introduction to evolutionary algorithms. Springer Science & Business Media
Yang, X.S. (2010). Engineering optimization: an introduction with metaheuristic applications. John Wiley & Sons

Boundary Layer Theory

ID: PhD-3586
responsible/holder professor: Ćoćić S. Aleksandar
teaching professor/s: Lečić R. Milan, Milićev S. Snežana, Stevanović D. Nevena, Ćoćić S. Aleksandar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
ECTS credits: 5
final exam: written+oral

goals
Fundamentals of boundary layer theory are studied in all basic courses in Fluid Mechanics. However, this theory is very complex for both laminar and turbulent flows. The aim of the course is to study all the relevant phenomena of the laminar and turbulent boundary layer, starting from Prandtl to the present day.

learning outcomes
The outcome of the course is to learn all the relevant boundary layer phenomena and master the balance equations of mass, momentum and energy with special applications to the boundary layer theory. Special emphasis is placed on the knowledge of the specific mathematical methods applied for boundary layer calculation.

theoretical teaching
General balance equations of fluid mechanics. Basic assumptions of the boundary layer - Prandtl equations of boundary layer for 2D incompressible flow. Integral characteristics of an incompressible and compressible boundary layer. Boundary layer integral equations. The Karman-Polhausen method. Solution of boundary layer equations by series development. Obtaining a solution near the separation point. SIMILAR SOLUTIONS. Exact solution for laminar boundary layer on flat plate - Blasius solution. Folkner-Scan solutions. Equations for compressible flow in the boundary layer. TURBULENT BOUNDARY LAYER. Turbulent incompressible boundary layer. Turbulent boundary layer on flat plate, Blasius solution, logarithmic velocity profile, velocity deficiency law. velocity profiles and friction laws. Intermittency in boundary layer. Flow separation criteria. Wake. Methods of series developmentin study of turbulent flows. Boundary layer of turbulent compressible flow. Boundary layer on flat plate - Van Driest solution. Application of integral methods. TRANSITION OF LAMINAR TO TURBULENT BORDER. Effects of pressure gradient, noise, wall curvature, wall roughness and suction of the boundary layer. Experimental methods for boundary layer flow research. Methods for numerically solving boundary layer equations.

practical teaching
Seminar works related to current problems of boundary layer theory.

prerequisite
--

learning resources
--

lecture hours of active teaching: 35

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

Schlihting H. , Gersten, K. Boundary Layer Theory, Springer 2017

CAD/CAM Systems and Integration of Product and Manufacturing Design

ID: PhD-3400
responsible/holder professor: Živanović T. Saša
teaching professor/s: Živanović T. Saša
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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.

Product design. Integration of CAD/CAM/CAE system. Geometric Modeling.

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.

Reverse engineering. Methods for rapid prototyping. Reconstruction of 3D models by using photogrammetric methods. Programming of machine tools based on * .STL file and machining parts on available machines.

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.

lecture hours of active teaching: 35

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

Xun Xu, Andrew Nee: Advanced Design and Manufacturing Based on STEP, Springer Verlag, London 2009.

Karlo Apro: Secrets of 5-Axis Machining.Industrial Press, New York 2008

Lewis C. (2008). A Pro/Engineers Guide to Pro/Web.Link, Printed on-demand by, www.lulu.com

Pierre Bourdet, Luc Mathieu : Geometric Product Specification and Verification: Integration of Functionality Kluwer Academic Publishers, New York, 2003

Zivanovic, S. (2012). Development of Educational Parallel Kinematic Machine. Zaduzbina Andrejevic, Beograd. (in Serbian)

CAI models

ID: PhD-3601
responsible/holder professor: Stojadinović M. Slavenko
teaching professor/s: Stojadinović M. Slavenko
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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 practicl 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
1. Advanced models for product modeling and metrological product models. 2. Metrological and geometrical features. 3. Semantic metrological model of tolerances. 4. Metrological interfaces. 5. CAI model and intelligent metrology. 6. Research problems in this area and elected examples of application. Our research in this area.

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. 4. Facility and technical equipment: Laboratory for production metrology and TQM.

lecture hours of active teaching: 35

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

Stojadinovic, M.S, Majstorovic, D.V., Durakbasa, M.N., & Sibalija, V.T (2016). Towards an intelligent approach for CMM inspection planning of prismatic parts. Measurement, 92, 326-339.
Stojadinovic, M.S., Majstorovic, D.V. (2019), An Intelligent Inspection Planning System for Prismatic Parts on CMMs, Springer International Publishing, 978-3-030-12806-7.
Durakbasa, M.N. (2004). Geometrical product specification and verification for the analytical description of technical and non-technical structures, TU Wienna, Austria.
Zhao, F., Brown, R.J., Kramer, T.R., Xu, X. (2011) Information Modeling for Interoperable Dimensional Metrology, Springer-Verlag, London.
Flack, D. (2001). CMM Measurement Strategies, Measurement Good Practice Guide No. 41, National Physical Laboratory, United Kingdom.

CFD in Combustion

ID: PhD-3317
responsible/holder professor: Adžić M. Miroljub
teaching professor/s: Adžić M. Miroljub, Milivojević M. Aleksandar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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. Adzic Handouts.

lecture hours of active teaching: 35

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
K. K. Kuo, Principles of Combustion, John Wiley, New York, 1986.
J. H. Ferziger, M. Peric, Computational methods for fluid dynamics, Springer Verlag 1999.

Cognitive robotics

ID: PhD-3429
responsible/holder professor: Miljković Đ. Zoran
teaching professor/s: Miljković Đ. Zoran
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Sensors: lasers, sonars and camera (stereo vision). Sensor models. Estimation of mobile robot pose – localization. Simultaneous localization and mapping (SLAM). Robot motion planning and future actions. Hybrid mobile robot control algorithm based on firefly method and homography visual servoing. Mobile robot learning of complex skills and autonomous behaviour based on examples provided by teacher: Learning from Demonstrations (LfD).

prerequisite
MSc degree of technically oriented faculty.

learning resources
1. Z. Miljković, M.M. Petrović, INTELLIGENT MANUFACTURING SYSTEMS – with excerpts from robotics and artificial intelligence, Textbook, XXVIII+409 p., University of Belgrade - Faculty of Mechanical Engineering, 2021 (I edition), 18.1 /In Serbian/

2. 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. Z. Miljković, SYSTEMS OF ARTIFICIAL NEURAL NETWORKS IN PRODUCTION TECHNOLOGIES, Monograph book within the Series Intelligent Manufacturing Systems, Vol. 8, University of Belgrade - Faculty of Mechanical Engineering, 2003, 18.1 /In Serbian/

4. 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.

5. Laboratory model of designed manufacturing system, Laboratory CeNT, University of Belgrade - Faculty of Mechanical Engineering.

6. Software packages (BPnet, ART Simulator, MATLAB®), Laboratory CeNT, University of Belgrade - Faculty of Mechanical Engineering.

lecture hours of active teaching: 35

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
R.Siegwart, I.R.Nourbakhsh, D.Scaramuzza, (2011) INTRODUCTION TO AUTONOMOUS MOBILE ROBOTS, 2nd Edition, The MIT Press.
E.Alpaydin, (2010) INTRODUCTION TO MACHINE LEARNING, 2nd Edition, The MIT Press, Cambridge, Massachusetts London, England.

Yang,X.S., (2010) ENGINEERING OPTIMIZATION: AN INTRODUCTION WITH METAHEURISTIC APPLICATIONS, Wiley.
Dudek,G., Jenkin,M., (2010) COMPUTATIONAL PRINCIPLES OF MOBILE ROBOTICS, Cambridge University Press.
Nolfi,S., Floreano,D., (2000) EVOLUTIONARY ROBOTICS: THE BIOLOGY, INTELLIGENCE, AND TECHNOLOGY OF SELF-ORGANIZING MACHINES, The MIT press.

Combined Cycles with Gas Turbines & Steam Turbines

ID: PhD-3367
responsible/holder professor: Petrović V. Milan
teaching professor/s: Petrović V. Milan
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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

Combined cycles and their applications. Thermodynamic background of the CCGT. Design and off-design performance of combined cycles. Advanced cycles. One-, two- and three- pressure cycles. The basic and main thermodynamic parameters. Performance and Economics. Energy and exergy analysis.

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.

lecture hours of active teaching: 35

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

Petrovic, M: Gas turbines and Turbocompressors, scrip, 2004.
Stojanovic, Themal Turbomachinery, Gradjevinska knjiga, Belgrade, 1967.
R.H. Kehlhofer Combined-Cycle Gas Steam Turbine Power Plants, PennWell 1999.
Horlock J.H.: Advanced Gas Turbine Cycles, Elsevier, 2003.
A.Bejan, G. Tsatsaronis, M. Moran: Thermal Design and Optimization, Wiley, 1996.

Combustion Modeling

ID: PhD-3316
responsible/holder professor: Adžić M. Miroljub
teaching professor/s: Adžić M. Miroljub, Milivojević M. Aleksandar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
lecture hours of active teaching: 35

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
J. Warnatz U. Maas, R.W. Dibble, Combustion, Springer, 2000.
K. K. Kuo, Principles of Combustion, John Wiley, New York, 1986.

Competitive Manufacturing Management

ID: PhD-3392
responsible/holder professor: Miljković Đ. Zoran
teaching professor/s: Miljković Đ. Zoran
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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.

* What to Master Schedule? The Flow Manufacturing Environment.

* 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.

* Manufacturing Strategy and Finishing Schedules based on Machine Learning and Advanced Techniques of Optimization.

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

lecture hours of active teaching: 35

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

John M. Nicholas, (1998) COMPETITIVE MANUFACTURING MANAGEMENT, Irwin McGraw-Hill.
John F. Proud, (2007) MASTER SCHEDULING, 3rd edition, John Wiley & Sons, Inc.
D.N. Prabhakar Murthy, Wallace R. Blischke, (2006) WARRANTY MANAGEMENT AND PRODUCT MANUFACTURE, Springer-Verlag London Ltd.
Thomas E. Vollmann, William L. Berry, D. Clay Whybark, F. Robert Jacobs, (2005) MANUFACTURING PLANNING AND CONTROL FOR SUPPLY CHAIN MANAGEMENT, McGrawHill.
E. Alpaydin, (2010) INTRODUCTION TO MACHINE LEARNING, 2nd Edition, The MIT Press, Cambridge, England.; E. Alpaydin, (2004) INTRODUCTION TO MACHINE LEARNING, The MIT Press, Cambridge, England.

Composite Materials Mechanics

ID: PhD-3514
responsible/holder professor: Balać M. Igor
teaching professor/s: Balać M. Igor
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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.

2. Macro mechanical elastic behavior of unidirectional lamina composites. The Hooke's Law for a two dimensional lamina. Determining stiffness of parallel arrays of fibers in matrix. Rules of mixture. Off-axis properties of a lamina.

3. Determining strength of unidirectional lamina. Analysis of failure criteria. Diverse failure criteria and their applications.

4. Macro mechanical elastic behavior of multidirectional composite laminates. Stress and strain analysis of single lamina, and of the entire composite material. General laminate plate theory. Studding of coupling effects – coupled flexure and torsion.

5. Stress – strain and failure analysis of multidirectional composite materials. Strength of lamina under tension and shear. Inter-laminar stresses. Laminate strength analysis. First ply failure.

practical teaching

1. Analytical examples of the assessment of macro mechanical properties of the composite materials.

2. Examples of the Hooke's law theory applied to the two dimensional unidirectional laminates. Determining of the stiffness matrix for the composite material.

3. Numerical exercises of stress strain analysis of laminate composites. Examples of determination of local and global values for stress and strain.

4. Numerical examples of determination of the ultimate strength using diverse failure criteria. Practical applications of failure theory to the ultimate strength calculations of mechanical components made out of composite materials.

5. Examples of numerical implementations of diverse modeling techniques of composite materials into the available codes. Comparison of numerical and analytical predictions of composite material component behavior.

prerequisite

Taken exams:

Strength of materials,

The base of strenght 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.

lecture hours of active teaching: 35

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

Computation Theory

ID: PhD-3225
responsible/holder professor: Radojević L. Slobodan
teaching professor/s: Bengin Č. Aleksandar, Mitrović B. Časlav, Radojević Lj. Slobodan
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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 нumbered 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.

lecture hours of active teaching: 35

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
N. Cutland: Computability: an introduction to recursive function theory, Cambridge University Press, 1980.

Computational Fluid Dynamics

ID: PhD-3557
responsible/holder professor: Simonović M. Aleksandar
teaching professor/s: Simonović M. Aleksandar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
ECTS credits: 5
final exam: written

goals
Educate students to understands foundatons 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
Computational grid generation. Transformation of flow equations between physical and computational domain. Potential flow simulation. Solution of Euler equations. Parabolized Navier-Stokes Equations, boundary layer flows. Solution of full Navier-Stokes Equations. Turbulence modelling. Turbulent models and flow simulations. High temperature flows

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

prerequisite
-

learning resources
Computer laboratory, laptop, projector

lecture hours of active teaching: 35

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
responsible/holder professor: Simonović M. Aleksandar
teaching professor/s: Bengin Č. Aleksandar, Simonović M. Aleksandar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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 efficency, Noice, 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

lecture hours of active teaching: 35

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
Ferziger J., Perić M., Computational Methods for Fluid Dynamics, Springer Verlag, 1999.
Katz J.,Race Car Aerodynamics: Designing for Speed, Bentley Publishers, 2003.
Selected research articles and conference papers.
Additional materials (lecture hand-writings, problem settings, task solving guidelines)

Computational Fracture Mechanics

ID: PhD-3611
responsible/holder professor: Đukić Z. Miloš
teaching professor/s: Đukić Z. Miloš, Sedmak S. Aleksandar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Elastic and elastic-plastic fracture mechanics. Fracture mechanics parameters. Stress intensity factor, crack tip opening, J integral. Application of fracture mechanics in structural integrity. Solving nonlinear problems using the FEM; types of nonlinearities, a review. Introduction to nonlinearity of the materials, the basics of the theory of plasticity. Presentation of the different criteria of plastic flow of materials in the FEM. The influence of building up the material. The influence of material anisotropy. The problem of heterogeneous materials - application on the welded joints. Problems of the material porosity. Viscoplasticity. Algorithms for solving nonlinear problems; incremental - iterative procedures. Nonlinearity of geometry; analysis of large deformations. Viscoelasticity. Nonlinear boundary conditions: solution for contact problems using formulation of FEM.Application of FEM in fracture mechanics and failure. Singular FE. Calculations of J-integrals in the FEM. Crack growth, techniques of node release. Determination of stress intensity factors using numerical methods. Adaptive finite element meshes and their application in the analysis of stress concentration. Numerical analysis in the local approach. The extended finite element method.

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 formulation of dynamic and impact loadings. Post-processing. Techniques of introducing residual stresses - application on different welding procedures. FEM solutions in assessing fracture integrity of the weld. Examples of calculating J-integral for welded joints. Numerical determination of stress intensity factors in the real structure. Numerical simulation of crack propagation using XFEM.

prerequisite
-

learning resources

[1] Written lessons from lectures (handouts)

[2] Kojic M., Computational Prrocedures in Inelastic Analysis of Solids and Structures, Kragujevac, 1997.

[3] Sekulović M., The finite element method, Građevinska knjiga, Beograd, 1988.

[4]A. Sedmak, Use of the fracture mechanics on the structure integrity assessment, Faculty of Mechanical Engineering, Belgrade, 2003.

[5] G Jovicic., Zivkovic M., S Vulović., Computational fracture mechanics and fatigue, Faculty of Mechanical Engineering, Kragujevac, 2011.

[6] Marko. P. Rakin, Local access to a ductile fracture of metallic materials. TMF, Belgrade, 2009.

[7] S. Sedmak, A. Sedmak, Experimental and numerical methods of fracture mechanics in structural integrity assesment, TMF, Belgrade, 2000.

lecture hours of active teaching: 35

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

Kojic M., Computational Prrocedures in Inelastic Analysis of Solids and Structures, Kragujevac, 1997.
Reddy J. N.,An Introduction to the Finite Element Method, McGraw-Hill: New York, 2005.
Mohammadi S., Extended finite element method for fracture analysis of structure, Blackwell Publishing Ltd., Oxford, UK, 2008.
O. C. Zienkiewicz, R. L. Taylor and J.Z. Zhu, The Finite Element Method: Its Basis and Fundamentals, Sixth Edition, 2005
T.L. Anderson, Fracture Mechanics: Fundamentals and Applications 3rd ed. CRC Press, London, 2005.

Computational Modeling in Mechanical Engineering

ID: PhD-3017
responsible/holder professor: Bengin Č. Aleksandar
teaching professor/s: Bengin Č. Aleksandar, Vorotović S. Goran, Mitrović B. Časlav
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Knowlege of C/C++ or FORTRAN languages is preferable.

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

lecture hours of active teaching: 35

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

Computational Multi-Fluid Dynamics

ID: PhD-3265
responsible/holder professor: Stevanović D. Vladimir
teaching professor/s: Stevanović D. Vladimir
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Balance equations for multiphase flow. Closure laws for interfacial transport phenomena. Control volume based numerical methods. SIMPLE type solving algorithms. Interface tracking techniques.

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.

Stevanović, V., Thermal-Hydraulics of Steam Generators – Modelling and Numerical Simulation, Monograph, Faculty of Mechanical Engineering, Belgrade, 2006.

Computer equipment.

Software for numerical solving of systems of differential equations of various types.

Software for simulation and analyses of pressure transients in pipeline networks and pressurized vessels.

Software for simulation and analyses of multidimensional two-phase flows.

lecture hours of active teaching: 35

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

Prosperetti, A., Tryggvason, G., Computational Methods for Multiphase Flows, Cambridge University Press, 2007.
Brennen, C.E., Fundamentals of Multiphase Flow, Cambridge University Press, 2005.
Stevanovic, V., Thermal-Hydraulics of Steam Generators – Modelling and Numerical Simulation, University of Belgrade, Faculty of Mechanical Engineering, 2006.
Kolev, N.I., Multiphase Flow Dynamics 1: Fundamentals, Springer, 2011.
Versteeg, H.K., Malalasekera, W., An introduction to Computational Fluid Dynamics, Longman Group Ltd., Harlow, 1995.

Computer Based Measurements

ID: PhD-3425
responsible/holder professor: Miljić L. Nenad
teaching professor/s: Miljić L. Nenad
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
ECTS credits: 5
final exam: project design

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

lecture hours of active teaching: 35

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
responsible/holder professor: Milošević-Mitić O. Vesna
teaching professor/s: Milošević-Mitić O. Vesna
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Introduction. Finite element modeling of the geometry of the supporting structures. The theory of elasticity. Finite element method. Line, surface and volume problems. Static and thermal analysis. Dynamic analysis. Analysis of the calculation of structure. Computer modeling and calculation of real problems. Load distribution in the structure. Diagnosis of the strength of structure behaviour. Elements of structure optimization.

practical teaching
Working with Programe package KOMIPS. The tasks from line primitives. The tasks of surface primitives. The tasks of volume primitives. Principles of computer modeling and generation of structure geometry. Adding primitives to generate finite element meshes. Computer modeling of supports and loads. Exercise of collecting primitives and generating network elements. Exercise of defining the characteristics of elements, supports and loads. Examples of static and thermal calculation. Examples of dynamic calculation. Diagnostics of structural behavior. Seminar papers from modelling, calculations, load distribution on the structure, analysis of structure calculation, defining elements of structure optimization.

prerequisite
No condition

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

lecture hours of active teaching: 35

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
responsible/holder professor: Motok D. Milorad
teaching professor/s: Motok D. Milorad
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Direct calculations of hull-girder torsion of a bulk carrier and container ship with wide hatch openings.Double hull tanker structures.Fatigue assessment of hull structure details.

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.

lecture hours of active teaching: 35

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
***: Ship Design and Construction, SNAME, 2003.
O. F. Hughes: Ship Structural Design, John Wiley & Sons, New York 1983.
A. Mansur: Strength of Ships and Ocean Structures, SNAME, 2008.
J.K.Paik and A.K. Thayamballi: Ultimate Limit State Design of Steel-Plated Structures,John Wiley & Sons, New York 2006.

Continuum Mechanics

ID: PhD-3405
responsible/holder professor: Mladenović S. Nikola
teaching professor/s: Mladenović S. Nikola
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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, thermical, electromagnetical and chemical effects. This is important for application of reached knowledge in engineering practice.

theoretical teaching
Continuum deformation. The concept of continuum. Basic concepts of kinematics. Material and spatial derivation in time. Velocity and acceleration. Deformation tensor. Small deformation. Deformation velocity tensor. Deformation velocity tensor invariants. Connections between deformation tensor and deformation velocity tensor. Basic principles of continuum mechanics. Transport theorem. The law of mass balance. Stress. Vector and stress tensor. Stress invariants. Major stresses. The law of momentum balance. The first and second laws of thermodynamics. The law of energy balance. Motion equations of various continua. Ideal elastic body. Linear classical elasticity theory. Thermoelasticity. The theory of plastic yielding. Ideal liquid. Newtonian and non-Newtonian liquids.

practical teaching
-

prerequisite
Defined by the curriculum study of Phd studies program.

learning resources
Jarić J.: Mehanika kontinuuma, Gradjevinska knjiga, Beograd, 1984.

Fomin V.: Mehanika kontinuuma dlja inženjerov, Izdateljstvo Lenjigradskovo Univerziteta, Lenjingrad, 1975.

Trusdel K.: Pervonačalnij kurs racionalnoj mehaniki splošnoj sredi, Mir, Moskva, 1975.

lecture hours of active teaching: 35

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

Jarić J.: Mehanika kontinuuma, Gradjevinska knjiga, Beograd, 1984.
Fomin V.: Mehanika kontinuuma dlja inženjerov, Izdateljstvo Lenjigradskovo Univerziteta, Lenjingrad, 1975.
Trusdel K.: Pervonačalnij kurs racionalnoj mehaniki splošnoj sredi, Mir, Moskva, 1975.

Cutting Theory

ID: PhD-3614
responsible/holder professor: Pjević D. Miloš
teaching professor/s: Pjević D. Miloš
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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 (dinamometry, 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 .

lecture hours of active teaching: 35

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
1.Kalpakjian S., Manufacturing Engineering and Technology , Addison-Wesley Pub.Com.,1995
Schey A. John , Introduction Manufacturing Processes, University of Waterloo, Ontario, 2000.

Konig W., Fertingungsverfahren Band 1 – Drehen, Frasen, Bohren, VDI Verlag,1990.
Novikov N.V., Sverhtverdie materiali. Polucenie i primenenie.monografia v 6 tomah, ISM NANU, Kiev, 2006
Tanović Lj., Petrakov Y.V., Theory and Simulation of the Machining Process, FME, Belgrade, 2007

Decision Theory

ID: PhD-3169
responsible/holder professor: Misita Ž. Mirjana
teaching professor/s: Misita Ž. Mirjana
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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.

lecture hours of active teaching: 35

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

Maynard, H.B, , 1971, Industrial Engineering Hadbook, McGraw Hill, New York, third edition, pp.1532
Bazerman, M.H., Moore, D.A, 2008, Judgment in managerial decision making, 7th ed., John Wiley and Sons, pp.230.
Blake, C., 2008, The Art of Decisions: How to Manage in an Uncertain World, Prentice Hall, pp.232
Adair, J.E., 2009 Effective Decision Making: The Essential Guide to Thinking to Management Success, Pac Macmillan, pp.192.
Zeleny, M., 1982, Multiple criteria decision making, McGraw-Hill, New York.

Design of Aerospace Structures

ID: PhD-3456
responsible/holder professor: Grbović M. Aleksandar
teaching professor/s: Grbović M. Aleksandar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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.

lecture hours of active teaching: 35

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.
Catia V5 Workbook: Release 14; Richard Cozzens, SDC Publications, 2006.

Design of Steam Turbines

ID: PhD-3390
responsible/holder professor: Petrović V. Milan
teaching professor/s: Petrović V. Milan
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Turbine aerodynamic design. 3D flow in steam turbines. Loss calculation. Optimal work factor and flow factor. Cascade design. Multistage steam turbines. Control stage design. HP-, IP-, LP-turbine flow path calculation. Steam turbine last stage design. Operating characteristics and off design behavior.

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

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

prerequisite
PhD student - Theraml power engineering

learning resources
Literature. Computing facility, software.

lecture hours of active teaching: 35

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

Petrovic, M.: Berechnung der Meridionalströmung in mehrstufigen Axialturbinen bei Nenn- und Teillastbetrieb, VDI-Verlag GmbH, Düsseldorf, 1995, 124 Seiten, ISBN 3-18-328007-8
Stojanovic, Themal Turbomachinery, Gradjevinska knjiga, Belgrade, 1967.
Traupel,W.: Thermische Turbomaschinen, Springer verlag, Berlin, 1982
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
responsible/holder professor: Mitrović B. Časlav
teaching professor/s: Bengin Č. Aleksandar, Vorotović S. Goran, Mitrović B. Časlav
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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.

lecture hours of active teaching: 35

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
responsible/holder professor: Jakovljević B. Živana
teaching professor/s: Jakovljević B. Živana
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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, 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, Hilbert-Huang 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 the 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 microcontrollers for practical realization in real-time Compilers

lecture hours of active teaching: 35

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

Jakovljević, Ž., Petrović, P., Contact states recognition in robotized assembly, University of Belgrade, Faculty of Mechanical Engineering, 2011, ISBN: 978-86-7083-750-8 (in Serbian)
Daubechies, I., Ten Lectures on Wavelets, CBMS-NSF regional conference series in applied mathematics, 61, Society for Industrial and Applied Mathematics, Philadelphia, Pennsylvania, 1992.
Mallat, S., A wavelet tour of signal processing, Academic Press, San Diego, California, 1999
Huang, N., E., et al., The empirical mode decomposition and the Hilbert spectrum for nonlinear and non-stationary time series analysis, Proceedings of Royal Society London, Vol. 454, pp 903-995, 1998
Popović, M., V., Digital Signal Processing, Nauka, Beograd, 1994. (in Serbian)

Dynamic problems of rail vehicles

ID: PhD-3569
responsible/holder professor: Milković D. Dragan
teaching professor/s: Milković D. Dragan
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Depending on PhD. thesis field, following subjects will be more or less deeply studied.

Non-linear modeling of the rail vehicles dynamic behavior. Multibody simulation tools. Eigenbehavior. Vehicle elastic body vibrations. Statistical methods for description of geometrical deviations of the track. Non-linear contact geometry. Methods for determination of the equivalent conicity. Counterformal and conformal wheel-rail contact. Non-linear wheel-rail contact models. Kalkers contact theories. Stability of motion. Critical speed. Hunting limit-cycle determination using simulation models. Non-linear curving models. Wheel-rail wear assessment criteria. Advanced assessment criteria of the dynamic behavior of rail vehicles: safety against derailment, track shift force, stability, ride characteristic, track loadings, ride comfort. Advanced tools in dynamic test result analysis. Longitudinal train dynamics. Noise sources and noise abatement methods. Interior and outside noise emission.

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

lecture hours of active teaching: 35

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

Knothe, K., Stichel, S, Schienefahrzeugdynamik, Springer Verlag,Berlin, 2003
Shabana, A., Zaazaa,K., Sugiyama,H., Railroadvehicle Dznamics, A Computational Approach, CRC Press,Boca Raton, 2007
Iwnicki, S., Handbook of Railway Vehicle Dynamics, CRC Press, Boca Raton, 2006
Garg,V., Dukkipati, R., Dynamic of Railway Vehicle Systems, Academic Press, 1984

Dynamics and Strength of Mining and Construction Machines

ID: PhD-3020
responsible/holder professor: Bošnjak M. Srđan
teaching professor/s: Bošnjak M. Srđan, Gnjatović B. Nebojša
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Dynamic models of single bucket excavator excavating devices. Impact of Bulldozer to the obstacle. Calculation of basic parameters of crushing and screening machines. Bucket wheel excavators and trenchers excitation modeling (determination). Analysis of bucket wheel excavators' and spreaders' structure response on excitation caused by external excitation. Consultations.

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

lecture hours of active teaching: 35

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.
Durst W, Vogt, W. Bucket Wheel Excavator. Clausthal-Zellerfeld: Trans Tech Publications; 1989.
Волков, Д. П., Черкасов, В. А.: Динамика и прочност многоковшовых экскаваторов и отвалообрзователей, Машиностроение, Москва, 1969.

Dynamics of a system of rigid bodies

ID: PhD-3122
responsible/holder professor: Lazarević P. Mihailo
teaching professor/s: Lazarević P. Mihailo
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Introduction to dynamics of system of rigid bodies (SRB). Fundamentals of kinematic chains.Orthogonal transformation of coordinates (OTC). Basic theory of finite rotations (FROT). FROT and spherical motion of rigid body. Quaternions. Hamilton-Rodriguez (HG) parameters. The transformation matrix in case of rotation in regard to (HG parameters and quaternions` notation), the application of the spherical motion SRB. Dynamics of spherical motion of the rigid body.The first integrals of differential equations (DIFE)of spherical motion of rigid body. Constraints of system, ideal and real constraints. The kinetic energy of the system of the rigid bodies.Metric tensor of system. Generalized forces and the principle of ideality RS- different cases -specially conservative case. The case of real constraints.

(DIFE) of motion of the RS in (contra)covariant form,quaternion form. DIFE of motion of RS given in the form of kinematic chain with the structure of topological three; DIFE of motion of RS given in the form of closed-kinematic chain.Additional equations of contraints. Optimal motion of system of rigid bodies. Variational approach.

Maximum-principle-application to real systems.

Fundamentals of system dynamics of deformable bodies and contact mechanics.

practical teaching
Examples of determining the OTC. Determining the number of degrees of freedom for a given SRB. Application of Rodriguez matrix transformation-typical cases. An example of determining the configuration of a case of SRB-an industrial machine. Examples of application of the finite rotation and quaternions in spherical rigid body motion. Instances of the spherical rigid body motion-typical cases. Determination of the kinetic energy of the system of rigid bodies as well as the metric tensor of SRB. Application on a concrete example: a mechanical model of washing machines 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

1.Wittenburg J.,Dynamics of Systems of Rigid Bodies,Teubner,Stuttgart,1977.(KSJ)

2.Čović M. V. Lazarević, Mechanics of Robot, MF Belgrade,2009.(Book)

3.Lazarević M. Exercises in mechanics of robot, MF Belgrade,2006.(ZZD)

4.Shabana A. Dynamics of Multibody Systems,2005.(KSJ)

5.Written abstracts from the lectures (Handouts)

6.Cyberbotics Webots - software package

7.Laboratory model of washing machine-4DOFs.

8.NeuroArm-laboratory robot-7 DOFs.

9.SimMechanics,GUI,(CSP)

lecture hours of active teaching: 35

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

Pfeiffer, F., Mechanical System Dynamics,Springer-Verlag Berlin Heidelberg,2008.
Ahmed A. Shabana,Computational Dynamics,John Wiley & Sons, Inc., 605 Third Avenue, New York, NY,2001
Coutinho, M., Dynamic Simulation of Multibody Systems, Birkäuser, 2001.
Schielen,W. ed., Multibody Systems Handbook, Springer-Verlag, Berlin, 1990
Roberson, R.E., Schwertassek, R., Dynamics of Multibody Systems, Springer-Verlag, Berlin, 1988.

Dynamics of material handling and conveying machines

ID: PhD-3079
responsible/holder professor: Zrnić Đ. Nenad
teaching professor/s: Zrnić Đ. Nenad
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Introduction into dynamics of material handling and conveying machines. Modeling support structure of a machine and drive units. Dynamic factors according to the existing standards. Discrete and continual models. Analysis of external loads (excitation). Obtaining natural frequencies of support structure of a material handling machine or conveyor by using Finite Elements Method. Effects of moving load on dynamic behavior. Moving load models: moving force, moving mass, moving oscillator. Wind effects on dynamics of structures. Obtaining dynamic response of the support structures of material handling and conveying machines. Analysis of obtained results. Evaluation of models. Comparison between various modeling approaches on dynamic response of a structure.

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
1. Nenad Zrnić: Dynamics of ship-to-shore container cranes, Zadužbina Andrejević, 2006.

2. Davor Ostrić: Dynamics of bridge cranes, Faculty of Mechanical Engineering Belgrade, 1998.

3. Milosav Georgijević: Dynamics of cranes, experimental and model analysis, Zadužbina Andrejević, 1996.

radić Mijaliović, Zoran Marinković, Miomir Jovanović: Dynamics and optimization of cranes, Faculty of Mechanical Engineering Niš, 2000.

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.

lecture hours of active teaching: 35

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
J. Verschoof : Cranes – Design, Practice, and Maintenance, Professional Engineering, 2002.
L. Fryba: Vibrations of solids and structures under moving loads, Thomas Telford, 1999.
Proceedings of the International Conferences on Material Handling, Constructions and Logistics, 2006, 2009, 2012

Ecodesign and sustainable logistics

ID: PhD-3402
responsible/holder professor: Zrnić Đ. Nenad
teaching professor/s: Zrnić Đ. Nenad
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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:

•model 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
Principles of ecodesign. Environmental impacts. Life cycle (LC) of a product. Environmental impacts of transport. Life cycle assessment (LCA). Goal and scope definition. Life cycle inventory (LCI). Life cycle impact assessment (LCIA). Interpretation of LC of a product. Software for LCA.

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
[1]Nenad Zrnić, Miloš Đorđević: Ecodesign - sustainable development of a product, FME, Belgrade, 2012.

[2]Bârsan A., Bârsan L.: Ecodesign for Sustainable Development, Volume 1 -

Fundamentals, Transilvania University of Brasov, Romania, 2007.

[3] Morris R.: Ecodesign for Sustainable Development, Volume 2 - Product

Life Cycle Assessment, University of Brighton, UK, 2007.

[4] Paralika M.: Ecodesign for Sustainable Development, Volume 3 - Product Recycling Technologies, T.E.I. of Athens, Greece, 2007.

[5] Wimmer W.: Ecodesign for Sustainable Development, Volume 4 - Product Development, Vienna University of Technology, Austria, 2007.

[6] Wimmer W., Züst R.: Ecodesign Pilot - Product Investigation, Learning and Optimization Tool for Sustainable Product Development, Kluwer Academic Publishers, Dordrecht, The Netherlands, 2003.

[7] Wimmer W., Zuest R., Lee K.: Ecodesign Implementation - A Systematic Guidance on Integrating Environmental Considerations into Product Development, Netherlands: Springer Verlag, 2004.

[8] Vezzoli C., Manzini E.: Design for Environmental Sustainability, Springer-Verlag, London, 2008.

[9] Ostad A. G. H.: Ecodesign - Sustainable Product Development, Vienna University of Technnology, Institute for Engineering Design, Ecodesign Research, 2006.

lecture hours of active teaching: 35

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

Bârsan A., Bârsan L.: Ecodesign for Sustainable Development, Volume 1 - Fundamentals, Transilvania University of Brasov, Romania, 2007.

Morris R.: Ecodesign for Sustainable Development, Volume 2 - Product Life Cycle Assessment, University of Brighton, UK, 2007.

Wimmer W., Züst R.: Ecodesign Pilot - Product Investigation, Learning and Optimization Tool for Sustainable Product Development, Kluwer Academic Publishers, Dordrecht, The Netherlands, 2003.

Wimmer W., Zuest R., Lee K.: Ecodesign Implementation - A Systematic Guidance on Integrating Environmental Considerations into Product Development, Netherlands: Springer Verlag, 2004.

Ostad A. G. H.: Ecodesign - Sustainable Product Development, Vienna University of Technnology, Institute for Engineering Design, Ecodesign Research, 2006.

Efficiency and reliability of weapon

ID: PhD-3590
responsible/holder professor: Marković D. Miloš
teaching professor/s: Elek M. Predrag, Jevtić T. Dejan, Marković D. Miloš
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
ECTS credits: 5
final exam: written

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

lecture hours of active teaching: 35

assessment of knowledge (maximum number of points - 100)

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

references

Przemensky P.: Mathematical modeling in defence analises, AIAA, 2005.
Eichblatt E.J.: Test and evaluation of tactical missile, AIAA ,Vol119, AIAA, 2001.
Driels M.R.: Weaponeering-Conventional Weapon System Effectiveness, AIAA, 2013.

End-of-life Vehicles

ID: PhD-3566
responsible/holder professor: Mitić R. Saša
teaching professor/s: Mitić R. Saša
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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

-

lecture hours of active teaching: 35

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

I. Blagojevic, S. Mitic: Vehicles and the Environment, Faculty of Mechanical Engineering, 2017.
European Commission – DG Environment: Ex-post evaluation of certain waste stream Directives, 2014
B.J. Jody, E.J. Daniels, C.M. Duranceau, J.A. Pomykala, Jr., and J.S. Spangenberger: End-of-Life Vehicle Recycling: State of the Art of Resource Recovery from Shredder Residue, 2010

Energy Efficiency in Buildings

ID: PhD-3577
responsible/holder professor: Sretenović A. Aleksandra
teaching professor/s: Sretenović Dobrić A. Aleksandra
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
ECTS credits: 5
final exam: written

goals
Training and education for both individual and team work in topics related to Energy efficiency in buildings. Development and implementation of complex technical solutions, related to the PhD thesis.

learning outcomes
After successful completion of the course, the student should be able to:

• critically analyze and implement complex technical solutions within the field of thermal science

• independently notice, define and solve technical problems using up-to-date methods

• independently, as well as team member, organize and conduct research in the field of energy efficiency in buildings

• have developed integral, holistic approach to the HVAC design in buildings

• successfully integrate local and central HVAC control and BMS

• apply energy efficiency measures and usage of HVAC systems

theoretical teaching
Basis of the efficient energy use in buildings. Integral (holistic) approach to building design. Thermal characteristics of building envelope. Heat transfer within building. Insulation. Windows, solar heat gains, natural daylight. HVAC systems: boilers, domestic hot water production, chillers, heat pumps, air handling units, heat recovery. Measurement and balancing in HVAC systems. Local and central control and BMS. Energy policies, energy rates, prices, tariff systems, role of participants in energy use. Maintenance of HVAC systems. Efficient usage of HVAC systems.

practical teaching
-

prerequisite
No specific requirements.

learning resources
-

lecture hours of active teaching: 35

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

ASHRAE Handbook - Fundamentals, ASHRAE Publication Sales, Tullic Circle NE, Atlanta Georgia 2009
ASHRAE Handbook - HVAC Applications, ASHRAE Publication Sales, Tullic Circle NE, Atlanta Georgia 2011
ASHRAE Handbook - HVAC Systems and Equipment, ASHRAE Publication Sales, Atlanta Georgia 2012
Sherrat, A.F.C: Air Conditioning System Design for Buildings, London, My Grow-Hill, 1984
Turner, W.C.: Energy menagement handbook, Fairmount Press, Lilburn, GA, 2001;

Engineering Anthropometry

ID: PhD-3468
responsible/holder professor: Spasojević-Brkić K. Vesna
teaching professor/s: Spasojević-Brkić K. Vesna
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
1. Roebuck, J. A., Kroemer, K. H. E., & Thomson, W. G. (1975). Engineering anthropometry methods (Vol. 3). New York: Wiley-Inderscience.

2. Tayyari, F., & Smith, J. L. (1997). Occupational ergonomics: principles and applications. London: Chapman & Hall.

3. Pheasant, S., & Haslegrave, C. M. (2005). Bodyspace: Anthropometry, ergonomics and the design of work. CRC Press.

4. Karwowski, W. (Ed.). (2001). International encyclopedia of ergonomics and human factors (Vol. 3). Crc Press.

5. Slides from Lectures

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

lecture hours of active teaching: 35

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

Roebuck, J. A., Kroemer, K. H. E., & Thomson, W. G. (1975). Engineering anthropometry methods (Vol. 3). New York: Wiley-Inderscience

Tayyari, F., & Smith, J. L. (1997). Occupational ergonomics: principles and applications. London: Chapman & Hall.

Pheasant, S., & Haslegrave, C. M. (2005). Bodyspace: Anthropometry, ergonomics and the design of work. CRC Press.

Karwowski, W. (Ed.). (2001). International encyclopedia of ergonomics and human factors (Vol. 3). Crc Press.

Scientific papers from Scopus, Science Direct and other databases

Engineering Management

ID: PhD-3348
responsible/holder professor: Spasojević-Brkić K. Vesna
teaching professor/s: Spasojević-Brkić K. Vesna
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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.

5. Supply Chain Management. Inventory Management.Just-In-Time concept.

5. Human Resources Management. Structuring high performance work arrangements.

6. Quality Management issues.

7. Maintenance Management, Reliability and Risk issues.

8. Financial Management issues - Financial Analysis and Forecasting.

9. Business performances.

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
1. C. M. Chang, Ching Ming Chang,Engineering management: challenges in the new millennium, Pearson Prentice Hall, 2005

2. Cole G. A, Management - Theory and Practice, Letts Educational,London, 2000.

3. W. Dale Compton, Engineering management: creating and managing world-class operations, Prentice Hall, 1997.

4. Tersine R.J., Production/Operations Management:Concepts, Structure and Analysis, Prentice Hall, 1985

5. John S. Oakland, Total Quality Management:Text with Cases, Elsevier Science & Technology, 2000

6. Slides from Lectures

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

lecture hours of active teaching: 35

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
C. M. Chang, Ching Ming Chang,Engineering management: challenges in the new millennium, Pearson Prentice Hall, 2005
Cole G. A, Management - Theory and Practice, Letts Educational,London, 2000.
W. Dale Compton, Engineering management: creating and managing world-class operations, Prentice Hall, 1997.
Papers from scientific databases.
John S. Oakland, Total Quality Management:Text with Cases, Elsevier Science & Technology, 2000

Environmental aspects of combustion

ID: PhD-3273
responsible/holder professor: Stojiljković D. Dragoslava
teaching professor/s: Jovanović V. Vladimir, Manić G. Nebojša, Stojiljković D. Dragoslava
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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 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

lecture hours of active teaching: 35

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

Joseph P. Reynolds, John S. Jeris, Louis Theodore, HANDBOOK OF CHEMICAL AND ENVIRONMENTAL ENGINEERING CALCULATIONS, John Wiley & Sons, Inc., New York, 2002.
Nicholas P. Cheremisinoff, Handbook of Air Pollution Prevention and Control, Elsevier Science, 2002.
Greenhouse gas emission trends and projections in Europe, EEA, 2002.
Prospects for CO2 Capture and Storage, IEA, 2004.

Epistemology of Science and Technique

ID: PhD-3549
responsible/holder professor: Zorić D. Nemanja
teaching professor/s: Zorić D. Nemanja
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
"Human and Culture: a symbol, a prehistory of techniques, Sumer, Egypt and Babylon. Epistemology and the beginnings of science and technology: a rational understanding of knowledge, Aristotle's concepts (technical and techniques).

Science and Technology in the Middle Ages: an empirical approach, a rational approach, modus tollens, modus ponens.

Science and technology in humanism and the Renaissance: from Cusanus . Hypotheses and astronomy: Copernicus, Brahe, Kepler. Movement and Cartesianism: Beckman, Descartes, Galileo and experimentum crucis.

Rational mechanics: Huygens, Newton, epistemics holistic, analytical mechanics. The hidden structure of metals. Evolution and the Industrial Revolution: a heat machine and arrow of time.

The world of atoms and quantum mechanics: quantum time and technique. Artificial intelligence: semantic information processing, microscopic cybernetics. Synergy and ecology.

practical teaching
-

prerequisite
-

learning resources
Crombie A.; Robert Grosseteste and the Origin of Experimental Science, 1100-1700, London, 1952.
Dijksterhuis E.; The Mehanization of the World Picture, Princeton, 1986.
Rousseau P.; Historie des Techniques, Paris, 1956.
Dijem, P., Cilj i struktura fizičkih teorija, Novi Sad, 2003.

lecture hours of active teaching: 35

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

Crombie A.; Robert Grosseteste and the Origin of Experimental Science, 1100-1700, London, 1952.
Dijksterhuis E.; The Mehanization of the World Picture, Princeton, 1986.
Rousseau P.; Historie des Techniques, Paris, 1956.
Dijem, P., Cilj i struktura fizičkih teorija, Novi Sad, 2003.

Especial Chapters of Theory of Machines and Mechanisms

ID: PhD-3564
responsible/holder professor: Jeli V. Zorana
teaching professor/s: Jeli V. Zorana, Popkonstantinović D. Branislav, Stojićević D. Miša
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
The formation of the theory of machines and mechanisms. Mechanisms and their classification. Structural analysis of the mechanism. Kinematic analysis of mechanisms. Analysis of the force. The process of constructing a machine.

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.

lecture hours of active teaching: 35

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
responsible/holder professor: Mitrović B. Časlav
teaching professor/s: Bengin Č. Aleksandar, Mitrović B. Časlav
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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

lecture hours of active teaching: 35

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
Fluid Mechanics Measurements, R.J. Goldstein (Ed.), Taylor Francis, Washington, 1996. TA357.F684.
Handbook of Flow Visualization, W-J Yang, 2nd edition, Taylor and Francis, 2001
Low-Speed Wind Tunnel Testing, Rae, W. and Pope, A.
Handbook of Experimental Fluid Mechanics, Tropea, Cameron; Yarin, Alexander L.;Foss, John F. Springer, 2007.

Experimental data acquisition and processing

ID: PhD-3427
responsible/holder professor: Kokotović M. Branko
teaching professor/s: Kokotović M. Branko
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Study curriculum and student motivation for learning experimental data acquisition and processing 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.

lecture hours of active teaching: 35

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
S. M. Pandit, S-H. Wu, Time series and system analysis, with applications, John Wiley & Sons, 1983, ISBN 0-471-86886-8.
H. G. Natke, Einfuerung in Theorie und Praxis der Zeitreihen- und Modalanalyse, Vieweg, 1983, ISBN 3-528-08145-7.
H. L. Wang, Eds, Identification of Continuous-time Models from Sampled Data, Springer, 2008, ISBN 978-1-84800-160-2.

J. Park, S. Mackay, Practical Data Acquisition for Instrumentation and Control Systems, Elsevier, 2003, ISBN 07506 57960.
T. L. Schmitz, K.S. Smith, Machining Dynamics, Frequency Response to Improved Productivity, Springer, 2009, ISBN 978-0-387-09644-5.

Explosive applications

ID: PhD-3542
responsible/holder professor: Elek M. Predrag
teaching professor/s: Elek M. Predrag, Micković M. Dejan
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
1. Jaramaz, S.: Physics of explosion, Faculty of Mechanical Engineering, Belgrade, 1997.

2. Zukas, J.A., Walters, W.: Explosive effects and applications, Springer, 1998.

lecture hours of active teaching: 35

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
Suceska, M.: Test methods for explosives, Springer, 1995.
Meyer, R., Kohler, J., Homburg, A.: Explosives, Wiley, 2002.

Failure Diagnostic

ID: PhD-3032
responsible/holder professor: Vencl A. Aleksandar
teaching professor/s: Vencl A. Aleksandar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
The role, objectives and techniques of failure analysis and condition-diagnostics in the construction and maintenance of mechanical systems (casual, permanent, partial, immediate and gradual failure). Failure analysis. The role of diagnostics and failure analysis in the maintenance of mechanical systems. Types of maintenance. Proactive maintenance. Benchmarking and road-map to excellence. Failures and analysis of maintenance costs. Management and technical strategy. Fault tree, FMEA analysis, Pareto analysis, etc. Types of failures in machine elements and systems. Failures case studies. Algorithms for the selection of monitoring methods. Analysis of results and corrective measures.

practical teaching
Preparing of the seminar paper.

prerequisite
No special requirements.

learning resources
1. A. Rac, Fundamentals of Tribology, Faculty of Mechanical Engineering, Belgrade, 1991, (in Serbian).

2. A. Rac, Lubricants and Machine Lubrications, Faculty of Mechanical Engineering, Belgrade, 2007, (in Serbian).

3. A. Rac, A. Vencl, Sliding Bearing Metallic Materials – Mechanical and Tribological Properties, Faculty of Mechanical Engineering, Belgrade, 2004, (in Serbian).

4. M. Babić, Monitoring of Lubricating Oils, Faculty of Mechanical Engineering, Kragujevac, 2004, (in Serbian).

5. Technical Diagnostic – Journal, (in Serbian).

lecture hours of active teaching: 35

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

E.D. Yardley, Condition Monitoring: Engineering the Practice, John Wiley and Sons, New York, 2002.
B. Jeremić, Terotechnology: Maintenance Technology of Technical Systems, Eskod, Kragujevac, 1992, (in Serbian).
R.A. Callacott, Mechanical Fault Diagnosis and Condition Monitoring, Chapman and Hall, London, 1977.
H. Braun (Ed.), Handbook of Loss Prevention, Springer, Berlin, 1978.

Fatigue and life estimation of aeronautical stuctures

ID: PhD-3415
responsible/holder professor: Grbović M. Aleksandar
teaching professor/s: Grbović M. Aleksandar, Dinulović R. Mirko, Simonović M. Aleksandar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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.

lecture hours of active teaching: 35

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

Manson S., Halford G., Fatigue And Durability of Structural Materials, ASM International, 2006.
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
responsible/holder professor: Grbović M. Aleksandar
teaching professor/s: Grbović M. Aleksandar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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 strucutures 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

2. Fatigue-Life Prediction: Total-Life and Safe-Life Approach; Damage-Tolerant Approach; Methods of Fatigue-Life Prediction at a Glance.

3. The K Concept of LEFM; Crack-Tip Plasticity: Concepts of Plastic-Zone Size and The J Integral.

4. Crack Initiation: Definition and Significance; Influence of Notches, Surface Treatment and Residual Stresses; Influence of Microstructual Factors on the Initiation of Fatigue Cracks.

5. FE and Analytical Calculations of Elastic Anisotropy Stresses to Predict Crack

Initiation Sites; ANSYS software.

6. Modeling Crack Propagation: Numerical Modeling of Short-Crack Propagation by Means

of a Boundary Element Approach; NASGRO and AFGROW softwares.

7. Modeling Crack Propagation: General Strategies of Fatigue Life Assessment; Numerical Modeling of Crack Propagation by Means of a Extended Finite Element Method (XFEM) Approach; ABAQUS and Salome MECA softwares.

8. Experimental Approaches to Crack Propagation: Crack-Propagation Measurements; Potential-Drop Concepts and Fracture Mechanics Experiments.

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.

lecture hours of active teaching: 35

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.
Hathaway R. et.al., Fatigue Testing and Analysis (Theory and Practice), Elsevier Inc., 2005.
Schijve J, Fatigue of Structures and Materials, Springer, 2009.

Finite element method

ID: PhD-3570
responsible/holder professor: Buljak V. Vladimir
teaching professor/s: Buljak V. Vladimir, Milošević-Mitić O. Vesna
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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

Introduction to numerical modeling. The application of virtual work principle for the formulation of stiffness matrix. Full and selective numerical integration. Coupled problems and solution strategy for two field and three field independent approximations. Constitutive modeling and its numerical implementation within FEM codes. The solution of dynamic problems. Implicit and explicit integration scheme. The stability of the solution.

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

1.Non-linear finite element analysis of solids and structures – Volume 1. M.A. Crisfield

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

3.An introduction to Nonlinear Finite Element Analysis. J.N Reddy

4.Computational methods in plasticity: Theory and applications. EA de Souza Neto, D. Peric and DRJ Owen.

lecture hours of active teaching: 35

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
An introduction to Nonlinear Finite Element Analysis. J.N Reddy
Computational methods in plasticity: Theory and applications. EA de Souza Neto, D. Peric and DRJ Owen.

Finite Elements Methods in Applications

ID: PhD-3342
responsible/holder professor: Grbović M. Aleksandar
teaching professor/s: Grbović M. Aleksandar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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

Organization of ANSYS Software, ANSYS Analysis Approach, ANSYS Preprocessor, ANSYS Solution Processor, ANSYS General Postprocessor, ANSYS Time History Postprocessor, ANSYS File Structure (Database File, Log File, ErrorFile, Results Files), Description of ANSYS Menus and Windows, Using the ANSYS Help System.

3. FUNDAMENTALS OF DISCRETIZATION

Local and Global Numbering, Approximation Functions, Coordinate Systems, Shape Functions

4. ANSYS PREPROCESSOR

Fundamentals of Modeling, Modeling Operations, Elements, Real Constants, Material Properties, Element Attributes, Solid Modeling, Boolean Operators, Meshing.

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

lecture hours of active teaching: 35

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.
Moaveni S Finite Element Analysis: Theory and Application with ANSYS, 3rd Edition, 2009.

Fluid measurements

ID: PhD-3593
responsible/holder professor: Ilić B. Dejan
teaching professor/s: Ilić B. Dejan
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
ECTS credits: 5
final exam: seminar works

goals
The main aim of the course is to refer the students in the specific fields of fluid measurements, and to prepare them for experimental research.

learning outcomes
Obtaining the knowledge of the fluid measurements necessary for quality scientific research, and gaining the ability to individually perform measurements.

theoretical teaching
Physical quantity measurements of incompressible and compressible flow. Classical and modern measuring techniques for pressure, velocity, and flow measurements. Calibration procedures for pressure, velocity and flow measuring devices. Velocity probe calibration in open jet wind tunnel. Velocity measurement of two- and three-dimensional flows using classical probes. Measurement accuracy and determination of measurement uncertainty.

practical teaching
Velocity and pressure measurements using classical probes.

Calibration of cylindrical and Conrad probes.

prerequisite
No prerequisites.

learning resources
[1] Hand-outs.

[2] Benišek M., Fluid Measurements, lecture handouts on Ph.D. (doctoral) studies, Faculty of Mechanical Engineering University of Belgrade, Belgrade.

[3] The experimental installation for velocity and pressure probe calibration, available in the laboratory.

[4] The experimental installation for calibration of the pressure devices, available in the laboratory.

lecture hours of active teaching: 35

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): 30

references

Ilić D. B., Ćantrak Đ. S. (2017): Manual for fluid flow measurements in laboratory, Fac. of Mechanical Eng. Univ. of Belgrade,Belgrade.

M Benišek., M Nedeljkovic., R Kilibarda., Gerasimović D. "The measurement techniques. Exercises in flow measurements", Mechanical Engineering, Belgrade 2000.

Fractional calculus with applications in engineering

ID: PhD-3128
responsible/holder professor: Lazarević P. Mihailo
teaching professor/s: Lazarević P. Mihailo
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Basic definitions and properties of fractional derivatives and integrals.

Cauchy type problem for ordinary fractional linear equations. Fractional existence and uniqueness theorems. Equations with the Riemann-Liouville fractional derivative. Equations with the Caputo derivatives in the space of continuous differentiable functions. Laplace transform method for solving ordinary differential equations with R-Liouville fractional derivatives.Laplace transform method for solving ordinary differential equations with Caputo fractional derivatives.Solution of Cauchy type problems for given fractional equations. Fractional order control.Numerical methods for fractional order systems.Applications with MATLAB for given fractional order system-examples in engineering.

practical teaching
Applications MATLAB for given fractional order systemc

-examples in engineering.

prerequisite
none

learning resources
1.M.Lazarević, Lj.Bučanović, Contribution to modelling and dinamical analysis of fractional order system with fundamentals of fractional calculus

2.Podlubny I. Fractional Differential Equations. Academic Press, San Diego,1999

3.Kilbas, Srivastava, H.M., Trujillo, J.J.Theory and Applications of Fractional Differential Equations. Elsevier, Amsterdam,2006.

4.Hilfer R, Ed., Applications of Fractional Calculus in Physics,World Scientific, River Edge, NJ, USA, 2000.

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

lecture hours of active teaching: 35

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

Oldham K B and J. Spanier, The Fractional Calculus: Theory and Applications of Differentiation and Integration to Arbitrary Order, Academic Press, New York, NY, USA, 1974

C. A. Monje, YQ. Chen, B. M. Vinagre, D. Xue, V. Feliu, Fractiona Order Systems and Controls – Fundamentals and Applications, Springer, 2010

K. S. Miller, B. Ross, An Introduction to the Fractional Calculus and Fractional Differential Equations, John Willey & Sons, Inc. 1993

R. Magin. Fractional Calculus in Bioengineering. Begell House, Inc. 2006

J.Sabatier,O Agrawal,J.Machado,ADVANCES IN FRACTIONAL CALCULUS,Springer,Netherlands,2007.

Fuels and selected topics in combustion

ID: PhD-3272
responsible/holder professor: Stojiljković D. Dragoslava
teaching professor/s: Jovanović V. Vladimir, Manić G. Nebojša, Stojiljković D. Dragoslava
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Energy sources. Energy reserves, production and consumption of fuels (solid, liquid and gaseous; natural and manufactured). Modern methods of fuel characterization - the application of modern methods of testing. Evaluation of fuel based on energy, environmental and economic criteria. Methods of fuel processing - modern techniques and development trends. Possibilities for application of fuels in various modern combustion processes.

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

lecture hours of active teaching: 35

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

Standard Handbook of Petroleum & Natural Gas Engineering, Vol. 1, 2, 3, Butterworth-Heinemann, 1996.
Carpenter A., Skorupska N., Coal combustion - Analysis and Testing, IEA, 1993.
Rutz D., Janssen R., Biofuel Technology Handbook, WIP Renewable Energies, 2007.
Energy Indicators for Sustainable Development: Guidelines and Methodologies, IAEA, 2005.
Reducing Greenhouse Gas Emission - The Potential of Coal, IEA, 2005.

Gas Turbines – Selected topics

ID: PhD-3370
responsible/holder professor: Petrović V. Milan
teaching professor/s: Petrović V. Milan
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Introduction. Application of gas turbines. Thermodynamic background. Thermodynamic cycles and thermal scheme. The basic and main thermodynamic parameters. The influence of basic parameters on the performance. Thermodynamic improvements. Advanced and complex thermodynamic cycles and schemes for gas turbines power plants.

Energy and exergy analyses of the gas turbine plants. The design of gas turbines. Cooling of turbine blades. Combustion chambers. Performance of gas turbines. Regulation of gas turbines.

Project: Heat balance calculation. Energy and exergy analysis.

practical teaching
Project: Heat balance calculation. Energy and exergy analysis.

prerequisite
PhD student - Thermal power engineering.

learning resources
Literature. Computing facility.

lecture hours of active teaching: 35

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

Petrovic, M: Gas Turbines and Turbocompressors, scrip, 2004.
Stojanovic, Themal Turbomachinery, Gradjevinska knjiga, Belgrade, 1967.
Traupel,W.: Thermische Turbomaschinen, Springer verlag, Berlin, 1982
Cumpsty, N.A , Compressor Aerodynamics, 1989 Longman Scientific and Technical, 2004 Krieger, 2004
Cohen, H., Rogers,G.F.C., Saravanamuttoo, H.I.H.: Gas turbine theory, Logman, 1997.

Gas-Liquid Two-Phase Flow and Heat Transfer

ID: PhD-3524
responsible/holder professor: Stevanović D. Vladimir
teaching professor/s: Stevanović D. Vladimir
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Two-phase flow patterns and maps. Two-phase flow parameters: void, static, flow and thermodynamic quality, slip, drift velocity, etc. Two-phase flow heat transfer. Boiling curve. Multi-fluid models of two-phase flow. Homogeneous and drift flux model. Closure laws for mass, mmentum and energy interfacial transfer. Boiling crisis. Chocked flow. Pressure waves propagation. Methods for the two-phase flow models solving. Interface tracking. Models validation and verification.

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.

lecture hours of active teaching: 35

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
Ghiaasiaan, S.M., Two-Phase Flow, Boiling, and Condensation in Conventional and Miniature Systems, Cambridge University Press, Cambridge, 2008.

Prosperetti, A., Tryggvason, G., Computational Methods for Multiphase Flows, Cambridge University Press, Cambridge, 2007.
Stevanovic, V., Thermal-Hydraulics of Steam Generators – Modelling and Numerical Simulation, University of Belgrade, Faculty of Mechanical Engineering, 2006.
Kolev, N.I., Multiphase Flow Dynamics 1: Fundamentals, Springer, Berlin, 2011.
Versteeg, H.K., Malalasekera, W., An introduction to Computational Fluid Dynamics, Longman Group Ltd., Harlow, 1995.

Guided missiles navigational systems

ID: PhD-3543
responsible/holder professor: Todić N. Ivana
teaching professor/s: Todić N. Ivana
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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, Rodriges'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
INS algorithms. Influence of sensor errors on inertial navigation. Calibration algorithms. Algorithms of integrated navigation systems.

prerequisite
none

learning resources
Titterton, D.H. and Weston, J.L., ”Strapdown Inertial Navigation Technology – 2nd edition”, IEE Radar, Sonar, Navigation and Avionic Series 17, ISPB 0-86341-358-7, 2004

Savage, P.G., ”Strapdown Inertial Navigation Integration Algorithm Design Part 1: Attitude Algorithms”, Journal of Guidance, Control, and Dynamics, Vol. 21, No. 1, pp. 19-28, Jan.-Feb. 1998

Savage, P.G., ”Strapdown Inertial Navigation Integration Algorithm Design Part 2: Velocity and Position Algorithms”, Journal of Guidance, Control, and Dynamics, Vol. 21, No. 2, pp. 208-221, Mar.-Apr. 1998

Salychev, O., “Inertial Systems in Navigation and Geophysics”, Bauman MSTU Press, ISBN 5-7038-1346-8, MOSCOW 1998

Salychev, O., “Applied Inertial Navigation: Problems and Solutions”, Bauman MSTU Press, ISBN 5-7038-2395-1, MOSCOW 2004

lecture hours of active teaching: 35

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

Titterton, D.H. and Weston, J.L., ”Strapdown Inertial Navigation Technology – 2nd edition”, IEE Radar, Sonar, Navigation and Avionic Series 17, ISPB 0-86341-358-7, 2004
Salychev, O., “Inertial Systems in Navigation and Geophysics”, Bauman MSTU Press, ISBN 5-7038-1346-8, MOSCOW 1998
Salychev, O., “Applied Inertial Navigation: Problems and Solutions”, Bauman MSTU Press, ISBN 5-7038-2395-1, MOSCOW 2004

Helicopter Rotor Aerodynamics

ID: PhD-3180
responsible/holder professor: Mitrović B. Časlav
teaching professor/s: Bengin Č. Aleksandar, Mitrović B. Časlav
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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

7.Helicopter Rotor Aerodynamic Characteristics in Vertical Climbing

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

lecture hours of active teaching: 35

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

High speed crafts

ID: PhD-3460
responsible/holder professor: Simić P. Aleksandar
teaching professor/s: Simić P. Aleksandar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
ECTS credits: 5
final exam: seminar works

goals
This course provides students with advanced knowledge on the hydrodynamics of high speed vessels, particularly with single-hull and multi-hull high speed crafts, hydrofoil crafts, air cushion crafts and small waterplane area twin hull vessels.

learning outcomes
1) Advanced knowledge about conventional types of high speed crafts.

2) Advanced knowledge about ship hydrodynamics needed for the design of conventional types of high speed crafts.

3) Ability to do calculations of ship resistance and propulsion of high speed crafts.

4) Knowledge about model-scale towing-tank tests and extrapolation of measured results to a ship scale.

theoretical teaching
Conventional high speed crafts (semi-displacement and planing single-hull and multi-hull crafts, hydrofoil crafts, air cushion crafts and small waterplane area twin hull vessels), hull-form characteristics, calculations of resistance and propulsion characteristics, towing tank model-scale tests, dynamic stability of high speed crafts, etc.

practical teaching
The focus is on the student’s independent design of high speed craft.

prerequisite
Defined by the curriculum of studies.

learning resources
Internet resources, books, scientific journals, commercial software in the field.

lecture hours of active teaching: 35

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
P. de Cane, High Speed Small Craft
P. Faltisen, Hydrodynamics of High Speed Marine Vehicles
Donald Blount, Performance by Design - Hydrodynamics of High-Speed Vessels, 2014.
L Yun, A Bliault, Theory and Design of Air Cushion Craft, 2000.

Human - machine interface 1

ID: PhD-3572
responsible/holder professor: Spasojević-Brkić K. Vesna
teaching professor/s: Spasojević-Brkić K. Vesna
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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 HMIs 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

1. Preece, J., Rogers, Y., Sharp, H., Benyon, D., Holland, S., & Carey, T. (1994). Human-computer interaction. Addison-Wesley Longman Ltd.

2. Nardi, B. A. (Ed.). (1996). Context and consciousness: activity theory and human-computer interaction. MIT Press.

3. Norman, K. L. (1991). The psychology of menu selection: Designing cognitive control at the human/computer interface. Intellect Books.

4. Salvendy, G. (2012). Handbook of human factors and ergonomics. John Wiley & Sons.

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

6. Slides from Lectures

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

lecture hours of active teaching: 35

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

Preece, J., Rogers, Y., Sharp, H., Benyon, D., Holland, S., & Carey, T. (1994). Human-computer interaction. Addison-Wesley Longman Ltd..

Nardi, B. A. (Ed.). (1996). Context and consciousness: activity theory and human-computer interaction. MIT Press.

Norman, K. L. (1991). The psychology of menu selection: Designing cognitive control at the human/computer interface. Intellect Books.

Salvendy, G. (2012). Handbook of human factors and ergonomics. John Wiley & Sons.

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

IC engines dynamic problems

ID: PhD-3424
responsible/holder professor: Miljić L. Nenad
teaching professor/s: Miljić L. Nenad
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
1. Dynamic equations of engine crankshaft motion. Mass moment of inertia of crank mechanism; variability of mass moment of inertia and its influence on crankshaft motion. Torques influencing crankshaft motion: gas force torques; inertia forces torques; friction torques; external load torques. Methods of crankshaft rotational speed variability reduction. Possibilities of engine working process diagnostics based on the measurement of crankshaft rotational speed variability.

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.

3. Experimental measurements of engine angular speed. Possibilities of experimental errors evaluation and their elimination.

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.

6. Forcing torques and their main harmonics evaluation. Engine critical rpm evaluation.

7. Experimental measurements of engine crankshaft torsional vibrations.

prerequisite

No prerequisites required.

learning resources

1. M.C. Živković: Internal combustion engines, part 2. Engine design 1, Kinematics and dynamics of piston mechanism. Faculty of Mech. Eng., Belgrade, 1983.

2. J.P Den Hartog: Mechanical Vibrations, New York Toronto London McGROW-HILL Book Company, 1956.

3. M.Tomić: Engine design 1-Handouts, available in PDF format in IC engines department.

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.

lecture hours of active teaching: 35

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

M.C. Živković: Internal combustion engines, part 2. Engine design 1, Kinematics and dynamics of piston mechanism. Faculty of Mech. Eng., Belgrade, 1983.
H. Maaß and H. Klier,Kräfte, Momente und deren Ausgleich in der Verbrennungskraftmaschine. Wien: Springer, 1981.
H. Maaß and H. Klier:Theorie der Triebwerksschwingungen der Verbrennungskraftmaschine, Springer, 1985.
H. Maaß and H. Klier:Torsionsschwingungen in der Verbrennungskraftmaschine, Springer, 1985.
A. S. Rangwala, Reciprocating Machinery Dynamics. New Age International, Jan. 2006.

Impact Mechanics

ID: PhD-3602
responsible/holder professor: Tomović M. Aleksandar
teaching professor/s: Tomović M. Aleksandar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
ECTS credits: 5
final exam: written

goals
The aim is that the issue of mechanical impact (collision) procedures as wide, and point outthe 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
Introduction. Analysis of low speed impact. Rigid body theory for collinear impact. Rigid body theory for planar or 2D collisions.3D impacts og rough rigid bodies. Rigid body impact with discrete modeling of compliance for the contact region. Continuum modeling of local deformation near the contact area. Axial impact on slender deformable bodies. Impact on assemblies of rigid elements. Collision against flexible structures. Special problems in impact mechanics.

practical teaching
Introduction. Analysis of low speed impact. Rigid body theory for collinear impact. Rigid body theory for planar or 2D collisions.3D impacts og rough rigid bodies. Rigid body impact with discrete modeling of compliance for the contact region. Continuum modeling of local deformation near the contact area. Axial impact on slender deformable bodies. Impact on assemblies of rigid elements. Collision against flexible structures. Special problems in impact mechanics.

prerequisite
Defined by the curriculum study of Phd studies program.

learning resources
[1] Pavišić,M., Golubović,Z., Mitrović,Z. Mechanics - Dynamics of mechanical systems,

Faculty of Mechanical Engineering, Belgrade, 2011.

[2] Stronge W.J. Impact Mechanics - Cambridge University Press, Cambridge, 2004.

lecture hours of active teaching: 35

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): 30

references

Goldsmith W., Impact, Dover Publications, N.Y., 2001.
Пановко.Я.Г., Введение в теорию механического удара, Наука, Москва, 1977.
Johnson K.L., Contact Mechanics, Cambridge Unev. Press, 1985.

Industrial Design

ID: PhD-3350
responsible/holder professor: Spasojević-Brkić K. Vesna
teaching professor/s: Spasojević-Brkić K. Vesna
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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 Assesment 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 defficiencies in human-machine systems. Design, conduct, and document a human factors experiment or study for a research project.

prerequisite

Enrolled semester.

learning resources

1. Guastello, S. J. (2006) Human factors engineering and ergonomics: A systems approach. Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

2. Norman, D. A. (2002). The design of everyday things. New York: Basic Books.

3. Sanders, M.S. and McCormick E.J. (1997). Human Factors in Engineering and Design (7th Ed.), McGraw-Hill, Inc.

4.Kroemer, K.H.E., Kroemer, H.B., and Kroemer-Elbert, K.E. (2001). Ergonomics: How to Design for Ease and Efficiency (2nd Ed.). Upper Saddle River, New Jersey: Prentice Hall.

5. Salvendy, G. (2012). Handbook of human factors and ergonomics. John Wiley & Sons.

6. Slides from Lectures

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

lecture hours of active teaching: 35

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

Guastello, S. J. (2006) Human factors engineering and ergonomics: A systems approach. Mahwah, NJ: Lawrence Erlbaum Associates, Inc.
Norman, D. A. (2002). The design of everyday things. New York: Basic Books.
Sanders, M.S. and McCormick E.J. (1997). Human Factors in Engineering and Design (7th Ed.)McGraw-Hill, Inc.
Kroemer, K.H.E., Kroemer, H.B., and Kroemer-Elbert, K.E. (2001). Ergonomics: How to Design for Ease and Efficiency (2nd Ed.). Upper Saddle River, New Jersey: Prentice Hall.
Salvendy, G. (2012). Handbook of human factors and ergonomics. John Wiley & Sons.

Industrial robots modelling and simulations

ID: PhD-3531
responsible/holder professor: Slavković R. Nikola
teaching professor/s: Slavković R. Nikola
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Kinematics and dynamics modelling of serial, parallel and hybrid industrial robots. Robot calibration. Off-line robot programming. Program simulation and verification. Configuring, modelling, and simulations of robotized cells and robotized workplaces.

practical teaching
Laboratory exercises are related to the theme of the PhD thesis and include: kinematics and dynamics robot modellidg, 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.

lecture hours of active teaching: 35

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

Parallel Robots, J. - P. Merlet, Kluwer Academic Publishers, 2000.
Introduction to Robotics in CIM Systems, fourth Ed., J. A. Rehg, Prentice Hall, 2000.
Industrial Robots Programming, Building Applications for the Factories of the Future, N. Pires, Springer, 2007.
Computer - Aided Manufacturing, Third Edition, T -C. Chang, R. A. Wysk, H - P. Wang, Prentice Hall, 2006.
Robotic and Automation Handbook, Edited by T. R. Kurfess, CRC Press, 2005.

Information Management

ID: PhD-3346
responsible/holder professor: Misita Ž. Mirjana
teaching professor/s: Misita Ž. Mirjana
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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 3. Object oriented analysis. Development of a conceptual model. Development of a sequence diagram. Development of completed class diagrams. Development of a state diagram. 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. 7. Communications of factories of the future. Communications in complex companies.

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.

lecture hours of active teaching: 35

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

references
Maynard, H.B, , 1971, Industrial Engineering Hadbook, McGraw Hill, New York, third edition, pp.1532
Turban E., Aronson E.J., Information technologies for management, Institute for textbook publishing and teaching aids, Belgrade, 2003.

Integrated Technical Systems - Actuators

ID: PhD-3466
responsible/holder professor: Miloš V. Marko
teaching professor/s: Miloš V. Marko
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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.

lecture hours of active teaching: 35

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
M. Milos: Integrated Technical Systems-Actuators – professor's handouts - Faculty of Mechanical Engineering, 2014.
N. Avgoustinov: Modelling in Mechanical Engineering and Mechatronics – Springer, 2007
R. Dorf, R. Bishop: Modern Control systems – Pearson, 2011.
W. Bolton: Mechatronics-Electronic Control Systems in Mechanical and Electrical Engineering – Pearson, 2012.
B. Wilamowski, D. Irwin: Control and Mechatronics – CRC Press, 2012.

Integration of smart actuators and sensors

ID: PhD-3205
responsible/holder professor: Petrović B. Nebojša
teaching professor/s: Petrović B. Nebojša
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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 challanges 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
Simlab - computer laboratory

lecture hours of active teaching: 35

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

Petrović N., Inteligentni piezoaktuatori, Mašinski fakultet Univerziteta u Beogradu, Beograd, 2003.
Janocha H., Adaptronics and Smart Structures: Basics, Materials, Design, and Applications, Springer,.1999.
Inman D., Vibration with control, John Wilez & Sons, 2006.
Selected research articles and conference papers.
Additional materials (written handouts, problem setting, guidelines for problem solving...)

Intelligent Automation

ID: PhD-3207
responsible/holder professor: Petrović B. Petar
teaching professor/s: Petrović B. Petar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Modeling and simulation of complex dynamical systems. Fundamentals of selforgnized and selfreproducing systems. Interaction with non-well structured/defined environment – cognitive systems, adaptivity, learning and machine intelligence. Fundamentals of mathematical pattern recognition. Fuzzy-dynamic formal structures, fuzzy inference machines. Connectionism and parallel processing through neural networks of various topology. Industrial control systems with embedded adaptive and intelligent behavior. Intelligent human-machine interfaces. Industrial standards related to intelligent devices and systems. Basics of intelligent manufacturing systems.

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.

lecture hours of active teaching: 35

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

Petrović P. B., Inteligentni sistemi za montažu, Mašinski fakultet u Beogradu, 1999.
Kasabov, N. and Kozma, R., (Eds) Neuro-Fuzzy Techniques for Intelligent Information Systems, Springer-Verlag Co. - Phisica-Verlag, Hilderberg New York, 1999, ISBN 3-7908-1187-4.
Kosko, B., Neural Networks and Fuzzy Systems: A Dynamical Systems Approach to Machine Intelligence, Prentice Hall; June 1991, ISBN-10: 0136114350.
Bolton, W., Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering, Prentice Hall, 2004, ISBN-10: 0131216333.
Zi-Xing Cai, Intelligent Control: Principles, Techniques And Applications, Series in Intelligent Control and Intelligent Automation: Volume 7, ISBN: 978-981-02-2564-3.

Intelligent industrial robots

ID: PhD-3530
responsible/holder professor: Slavković R. Nikola
teaching professor/s: Slavković R. Nikola
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Modelling of serial, parallel and hybrid industrial robots. Redundant robots. Macro/micro and micro/nano robot structures. Advance basic robots' subsystems. Sensors fusion, vision systems and intelligence. Intelligent path planning. Programming and simulation. Complex industrial tasks and new fields of industrial robot applications.

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.

lecture hours of active teaching: 35

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

Modelling and control of robot manipulators, L. Sciavicco and B. Siciliano, Springer, 2005.
Mechatronics, principles and applications, G. C. Onwubolu, Elsevier, 2005.
Introduction to Robotics, Analysis, Systems, Applications, S. B. Niku, Prentice Hall, 2001.
Robot analysis, The Mechanics of Serial and Parallel Manipulators, Lung-Wen Tsai, John Wiley & Sons, 2003.
Robotics: Control, Sensing, Vision, and Intelligence, Fu K.S., Gonzales R.C., Lee C.S.G., McGraw-Hill, New York, 1987.

Introduction to Operations Research

ID: PhD-3520
responsible/holder professor: Bugarić S. Uglješa
teaching professor/s: Bugarić S. Uglješa
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Introduction. Problem classification. Linear programming (graphical solution, simplex method, dual theory, sensitivity analysis). Transportation problem (open and closed). Nonlinear programming. Dynamical programming, Project management (structure analysis, time analysis using PERT/CPM, critical path, cost analysis – PERT/Cost). Service systems – Queuing theory (queuing theory models – single and multi server with out and with partial and complete help between servers, with finite and infinite source of customers, optimisation of service systems). Simulation of service systems (approach to simulation, Monte Carlo method, generation of random numbers, processing and presentation of simulation results). Decision analysis. Forecasting (forecasting methods).

practical teaching
Audit lessons (examples of linear programming, transportation problem, nonlinear programming, dynamical programming. Examples of project management – structure analysis, time analysis cost analysis.

Examples of application of queuing theory models – finite and infinite source of customers, single and multi server without and with partial and complete help between servers.

Examples of service system optimisation. Application of simulation and Monte Carlo method in analysis and modelling of service systems. Examples from area of decision making and forecasting.).

Laboratory work (the use of adequate software).

prerequisite
Students should have a background in probability, statistics, mathematics, computer science.

learning resources
1. Software: QtsPlus 3.0 (Queuing theory software Plus).

2. Software: QSopt Version 1.0 (Linear programming problems).

3. Software: IOR Tutorial (Interactive Operations Research).

4. Software: MS – Project (Project management).

5. Personal computers.

lecture hours of active teaching: 35

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), McGraw-Hill, New York, 2000.

Churchman, C. W., Ackoff, R. L., Arnoff, E. L.: Introduction to Operations research, John Willey & Sons Inc., 1957.

Inverse analysis in material characterization

ID: PhD-3512
responsible/holder professor: Buljak V. Vladimir
teaching professor/s: Buljak V. Vladimir
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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

1. Inverse analyses with model reduction: Proper Orthogonal Decomposition in Structural Mechanics. Springer Verlag, 2012. Vladimir Buljak

2. Numerical Optimization. Springer Verlag, 2000. Jorge Nocedal and Stephen Wright.

3. Inverse problem theory and methods for model parameter estimation. SIAM, Society for Industrial and Applied Mathematics. A Tarantola

lecture hours of active teaching: 35

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
responsible/holder professor: Peković M. Ognjen
teaching professor/s: Peković M. Ognjen
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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 achievments 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.

prerequisite
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

lecture hours of active teaching: 35

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
Cottrell J.A., Hughes T.J.R., Bazilevs Y., 2009, Isogeometric Analysis: Toward Integration of CAD and FEA, John Wiley & Sons, Chichester
Piegl L., Tiller W., 1997, The NURBS Book, Springer-Verlag New York, New York
Rogers D., 2001, An Introduction to NURBS With Historical Perspective, Morgan Kaufmann Publishers, San Francisco
Hughes TJR, 1987, The finite element method. Linear Static and Dynamic Finite Element Analysis, Prentice-Hall, Inc., Englewood Cliffs, New Jersey
Bathe KJ., 1982, Finite element procedures in engineering analysis, Prentice-Hall, Inc., Englewood Cliffs, New Jersey

Load distribution - Analysis and Synthesis - 1

ID: PhD-3622
responsible/holder professor: Mitrović M. Radivoje
teaching professor/s: Ristivojević R. Mileta
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
ECTS credits: 5
final exam: project design

goals
Acquiring knowledge in the area of machine elements load distribution (gears, bearings, threaded joints, chain transmission,...) regarding efficiency and operational capability. Knowledge and skils improvement. Synthesising the acquired knowledge and skills with previously acquired knowledge. Establishing a correlation between the intensity of the load to be transferred and stiffness and accuracy of composite parts in order to achieve proper load.

learning outcomes
Students will be able to: use the scientific literature on selected areas from

the scope of Course; independently solve a scientific-research problems from selected area (making of appropriate analytical, numerical and experimental models); individually or as a team member, to write scientific research papers; ability to transfer knowledge and skills to others.

theoretical teaching
Gear pairs load distribution. Load distribution on the coupled pairs of gear's teeth. Defining of load distribution analytical model. Boundary load distribution (uniform and uneven) and real load distribution. Influence factors. Contact line lenght analysis regarding to load distribution uniformity. Boundary conditions defining. Influence of load intensity, stiffness and gear teeth production accuracy on load

distribution in operational conditions. Load distribution influence on gear teeth capacity. Rolling bearing load distribution. Load distribution between rolling bearing components. Boundary load distributions. Influence factors. Influence of load intensity, stiffness, radial clearance and number of rolling bodies on load

distribution. Influence of load distribution on rolling bearing's service life and capacity.

practical teaching
Depending on candidates narrow interests the laboratory resources for general machine design are available.

prerequisite
-

learning resources
Laboratories of Machine design, University of Balgrade, Faculty of Mechanical

Engineering. Handouts, Presentations, Wireless Internet connection and access to the course Web presentation provided with usefull links.

lecture hours of active teaching: 35

assessment of knowledge (maximum number of points - 100)
feedback during course study: 0
test/colloquium: 20
laboratory exercises: 20
calculation tasks: 5

seminar works: 25
project design: 0
final exam: 30
requirements to take the exam (number of points): 0

references

M.Ristivojević, R.Mitrović: Load Distribution - Gear Pairs and Rolling bearings, Belgrade, 2002.
Karl-Heinz Decker: Machinenelemente: Funktion, Gestaltung und Berechnung, Hanser Verlag, 2000
R.Mitrovic: PhD thesis, Faculty of Mechanical Engineering University of Belgrade, 1992.
M.Ristivojevic: PhD thesis, Faculty of Mechanical Engineering University of Belgrade, 1991.

Load distribution - Analysis and Synthesis - 2

ID: PhD-3176
responsible/holder professor: Mitrović M. Radivoje
teaching professor/s: Mitrović M. Radivoje
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
ECTS credits: 5
final exam: seminar works

goals
Acquiring knowledge in the area of machine elements load distribution (gears, bearings, threaded joints, chain transmission,...) regarding efficiency and operational capability. Knowledge and skils improvement. Synthesising the acquired knowledge and skills with previously acquired knowledge. Establishing a correlation between the intensity of the load to be transferred and stiffness and accuracy of composite parts in order to achieve proper load.

learning outcomes
Students will be able to: use the scientific literature on selected areas from the scope of Course; independently solve a scientific-research problems from selected area (making of appropriate analytical, numerical and experimental models); individually or as a team member, to write scientific research papers; ability to transfer knowledge and skills to others.

theoretical teaching
Gear pairs load distribution. Load distribution on the coupled pairs of gear's teeth. Defining of load distribution analytical model. Boundary load distribution (uniform and uneven) and real load distribution. Influence factors. Contact line lenght analysis regarding to load distribution uniformity. Boundary conditions defining. Influence of load intensity, stiffness and gear teeth production accuracy on load distribution in operational conditions. Load distribution influence on gear teeth capacity. Rolling bearing load distribution. Load distribution between rolling bearing compšonents. Boundary load distributions. Influence factors. Influence of load intensity, stiffness, radial clearance and number of rolling bodies on load distribution. Influence of load distribution on rolling bearing's service life and capacity.

practical teaching
The experiment setting, the flow and analysis of experimental results.

prerequisite
None

learning resources
Laboratory of Machine design, University of Balgrade, Faculty of Mechanical Engineering. Handouts, Presentations, Wireless Internet connection and access to the course Web presentation provided with usefull links.

lecture hours of active teaching: 35

assessment of knowledge (maximum number of points - 100)

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

references

M.Ristivojević, R.Mitrović: Load Distribution - Gear Pairs and Rolling bearings, Belgrade, 2002.
Karl-Heinz Decker: Machinenelemente: Funktion, Gestaltung und Berechnung, Hanser Verlag, 2000
R.Mitrovic: PhD thesis, Faculty of Mechanical Engineering University of Belgrade, 1992.
M.Ristivojevic: PhD thesis, Faculty of Mechanical Engineering University of Belgrade, 1991.

Lubrication Theories

ID: PhD-3033
responsible/holder professor: Vencl A. Aleksandar
teaching professor/s: Vencl A. Aleksandar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
1. A. Rac, Fundamentals of Tribology, Faculty of Mechanical Engineering, Belgrade, 1991, (in Serbian).

2. A. Rac, Lubricants and Machine Lubrications, Faculty of Mechanical Engineering, Belgrade, 2007, (in Serbian).

3. J. Halling, Principles of Tribology, The MacMillan Press, London, 1975.

4. O. Pinkus, B. Sternlicht, Theory of Hydrodynamic Lubrication, McGraw-Hill, New York, 1961.

5. Y. Hori, Hydrodynamic Lubrication, Springer, Tokyo, 2006.

6. B.J. Hamrock, S.R. Schmid, B.O. Jacobson, Fundamentals of Fluid Film Lubrication, Marcel Dekker, New York, 2004.

7. D. Dowson, G.R. Higginson, Elasto-Hydrodinamic Lubrication, Pergamon Press, Oxford, 1977.

lecture hours of active teaching: 35

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

A.Z. Szeri, Tribology: Friction, Lubrication, and Wear, McGraw-Hill, New York, 1980.
D. Dowson, C.M. Taylor, M. Godet, D. Berthe (Eds.), Developments in Numerical and Experimental Methods Applied to Tribology, Butterworths, London, 1983.
W.A. Gross, L.A. Matsch, V. Castelli, A. Eshel, J.H. Vohr, M. Wildmann, Fluid Film Lubrication, John Wiley & Sons, New York, 1980.
O.R. Lang, W. Steinhilper, Gleitlager, Springer, Berlin, 1978.
S. Bair, High Pressure Rheology for Quantitative Elastohydrodynamics, Elsevier, Amsterdam, 2007.

Lubrication Theory

ID: PhD-3588
responsible/holder professor: Ćoćić S. Aleksandar
teaching professor/s: Lečić R. Milan, Ćoćić S. Aleksandar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
ECTS credits: 5
final exam: written

goals
Introduction to hydrodynamic lubrication theory, its application and mathematical methods for calculating the flow in bearings.

learning outcomes
Mastering physical and mathematical methods of calculation of flow in bearings of variable geometry with Newtonian (incompressible or compressible) or non-Newtonian fluid, or dilute gas.

theoretical teaching
1. General equations.

2. Fluid film.

3. Dynamic properties of fluid film

4. Effects of fluid inertia

5. Flow stability and transient modes

6. Turbulence

7. Elasto-hydrodynamic lubrication theory

8. Thermal effects

9. Non-Newtonian fluids

practical teaching
Seminar work on given topic.

prerequisite
-

learning resources
lecture hours of active teaching: 35

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
Szeri Z. Andras: Fluid Film Lubrication,Theory and Desing, Cambridge University Press, 1998.

Machine Dynamics

ID: PhD-3563
responsible/holder professor: Šiniković B. Goran
teaching professor/s: Šiniković B. Goran
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Typical machine and mechanism configurations. Examples. Decomposition mode of complex shapes. Mass and inertia discretization. Compiling 3D models. Virtual Dynamic Testing. Balancing the mechanism. Examples. Articulated four-leggings, piston mechanism, multi-cylinder piston assemblies (linear and V-configuration). ISO standard in the domain of vibration, balancing, modal testing, flexible rotor and support structures. Equipment for laboratory and field dynamic testing. Test procedures. Folding, idea and priming. Reluctant structures and their dynamics. Vibration absorbers, solutions in application.

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

lecture hours of active teaching: 35

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
responsible/holder professor: Lečić R. Milan
teaching professor/s: Lečić R. Milan
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Governing equations of Magnetohydrodynamics. Similiraty criteria. Laminar flow of conductive fluid in lateral and longitudinal magnetic field. Laminar flow between parallel plates, in rectangular channels and circular pipes. Stability of laminar flow. Influence of magnetic field to flow disturbances and transition to turbulence. Turbulent flow in pipes with presence of lateral and longitudinal magnetic field. Flow around flat plate and cylinder with presence of lateral magnetic field. Magnetohydrodynamic flow of Stokes and Osen. Magnetohydrodynamic boundary layer. Hydraulic calculations of magnetohydrodynamic pump and electro-conductive surge bin for liquid metals.

practical teaching
Research on a specific problem of Magnetohydrodynamics.

prerequisite
Passed exam in Selected Chapters in Fluid Mechanics.

learning resources
lecture hours of active teaching: 35

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
J. A. Shercliff: A textbook of magnetohydrodynamics, Pergamon Press, Oxford 1965.

Maintenance and Quality Management System

ID: PhD-3261
responsible/holder professor: Spasojević-Brkić K. Vesna
teaching professor/s: Bugarić S. Uglješa, Veljković A. Zorica, Spasojević-Brkić K. Vesna
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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. Organizatinal Design Factors and maintainance system 4. The organizational structure of the maintenance function 5. Quality Menagement System and organizational changes 6. Quality management and business performances relationship 7. Integrated Management Systems.

practical teaching
Case studies in the areas of theory in form of seminal work with possible paper publication.

prerequisite
Enrolled semester

learning resources
1. Spasojević Brkić Vesna, Contingency Theory and Quality Management, MNTRS- FME, ISBN 978-86-7089-675-4, 2009.

2. Smith R., Hawkins B., Lean maintenance : reduce costs, improve quality, and increase market share, Elsevier Butterworth–Heinemann, Oxford, UK, 2004

3. Kelly A., Managing Maintenance Resources, Elsevier Ltd., Oxford, UK, 2006

4.Milivoj Klarin,Gradimir Ivanović,Petar Stanojević - Terotechnology (in Serbian) - ICIM Kruševac 2001

5. Spasojević-Brkić, V, Milanovic D, i dr., Quality management System and Business Performances (in serbian),MNTRS- FME,ISBN: 978-86-7083-741-6 ,2012.

6. Scientific resources on Scopus, Science Direct etc.

lecture hours of active teaching: 35

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

Spasojević Brkić Vesna, Contingency Theory and Quality Management, MNTRS- FME, ISBN 978-86-7089-675-4, 2009.
Kelly A., Managing Maintenance Resources, Elsevier Ltd., Oxford, UK, 2006
Milivoj Klarin,Gradimir Ivanović,Petar Stanojević - Terotechnology (in Serbian) - ICIM Kruševac 2001
Spasojević-Brkić, V, Milanovic D, etc. Quality management System and Business Performances (in serbian),MNTRS- FME,ISBN: 978-86-7083-741-6 ,2012.
Scientific resources on Scopus, Science Direct etc.

Man - machine interface

ID: PhD-3075
responsible/holder professor: Žunjić G. Aleksandar
teaching professor/s: Žunjić G. Aleksandar, Spasojević-Brkić K. Vesna
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Designing of specific controls. Designing of displays for qualitative and status control. Basic safety aspects of packaging. Injuries caused by inadequate packaging. Packaging of hazardous material. Other safety aspects of packaging. Informational aspect of packaging. Most frequent mistakes relating to the presentation of information. Most frequent mistakes concerning opening of packaging. Forces for opening of packaging. Tools for opening of packaging. Recommendations for designing of ergonomic packaging.

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.

lecture hours of active teaching: 35

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

Handbook of human factors and ergonomics in consumer product design: uses and applications, 2011, Edited by Karwowski W., Soares M. and Stanton N., Taylor & Francis, London.
Sanders M. and McCormick E., 1993, Human factors in engineering and design, McGraw - Hill, Singapore.

Management of Innovation

ID: PhD-3487
responsible/holder professor: Dondur J. Nikola
teaching professor/s: Dondur J. Nikola, Misita Ž. Mirjana
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
ECTS credits: 5
final exam: written

goals
As innovation is crucially important for business growth, it is essential

to establish Innovation Management as a core competency.

The main goal of program of the subject Management of Innovation is preparing students for a management and research career in contemporary dynamic market environment through a management core, combined with advanced insights in innovation and entrepreneurship.

Also, the aim of this program is to help students for innovation within their company to expand their general management and leadership competencies - with a strong focus on the management of technology. In fact, this program will bridge technology, innovation, management and leadership.

learning outcomes
The program enables student to adopt the following subject knowledge and understanding, intellectual and academic skills, practical subject skills, key attributes and transferable skills.

The outcomes that it will have demonstrated upon completion of the program, are the abilities to: learn the key principles of innovation management; understand the key issues in managing innovation first of all in manufacturing and service; set a clear direction through the development of an innovation strategy that focuses on creating new products and services that bring sustainable competitive advantage in turbulent market environment.

theoretical teaching
The four main types of innovation: product, service, process and business innovation. Global innovation and R&D strategy - Managing emerging technologies - Technology and development - Service design and innovation - Sustainable and clean-tech innovation. Impacts of information technology upon individuals, organizations and society - Open source innovation - Business model innovation. Sociological aspects of technology, work and innovation - Knowledge management - Virtual Organizations - Project Management – Technology Assessment and Prognostic -Measures of innovation - The innovation audit. Intellectual property rights – preparation of a patent - licensing agreements, etc. State and innovation: international comparison. International transfer of technology.

practical teaching
The practical work is consisted from discussion and workshops with special topics as well as characteristic industrial cases from local and word practice. Special attention will be paid to the problem of technological innovations as a key factor of competitiveness. Beside that, practical work is used for preparation of seminar paper.

prerequisite
At least 60 points, when points from the practical exam are especially important.

learning resources
-

lecture hours of active teaching: 35

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

Betz, F. (2003), Managing Technology Innovation: Competitive Advantage from Change, N. Y.
Besant, J., Tidd, J., Pavitt, K., (2001), Managing Innovation, Willey, N. Y.
Ettlie, J., (2006), Managing Innovation: New Technology, New Product and New Services in a Global Economy, Butterworth-Heinemann, London
Trott, P., (2008), Innovation Management and New Product Development, Prentice Hall,

Management of production

ID: PhD-3154
responsible/holder professor: Milanović D. Dragan
teaching professor/s: Veljković A. Zorica, Milanović D. Dragan, Misita Ž. Mirjana, Spasojević-Brkić K. Vesna
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
ECTS credits: 5
final exam: written

goals
Acquisition of skills necessary for the field of management of production.

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

- determine the business and manufacturing processes of production management,
- distinguish between the key management processes,
- discuss the improvement of management,
- initiate the use of management information systems,
- solve the identified problems in production management,
- participate in solving a case study in a manufacturing company.

theoretical teaching
1. Goals and tasks of management of production 2. Management of business functions in a manufacturing company 3. Analysis of business functions in a manufacturing company 4. Management of information systems 5. Computer planning and management of production 6. Manufacturing cycle 7. Optimization of internal resources aimed at more efficient management of production 8. A case-study in a manufacturing company

practical teaching
A case-study from the field of management of production.

prerequisite
No specific enrolment requirements.

learning resources
lecture hours of active teaching: 35

assessment of knowledge (maximum number of points - 100)
feedback during course study: 5
test/colloquium: 25
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
Bulat, V., Organization of production, Faculty of Mechanical Engineering, Belgrade, 1990.

Mass, momentum and energy transport phenomena

ID: PhD-3268
responsible/holder professor: Stevanović D. Nevena
teaching professor/s: Stevanović D. Nevena
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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.

lecture hours of active teaching: 35

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
Slattery, J.C., Advanced Transport Phenomena, Cambridge University Press, 1999
Bird, R.B.,Stewart, W.E., and Lightfoot, E.N., Transport Phenomena, John Wiley, New York, 2007

Mathematical methods in fluid mechanics

ID: PhD-3158
responsible/holder professor: Milićev S. Snežana
teaching professor/s: Lečić R. Milan, Milićev S. Snežana, Stevanović D. Nevena, Ćoćić S. Aleksandar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Tensors. Tensor algebra and tensor calculus. Partial differential equations (PDE). Classification of PDEs. Elliptic, hyperbolic and parabolic PDEs. Methods for solving partial differential equations. Methods of characteristics. Numerical methods in fluid mechanics. Finite difference and finite volume method. Finite elements method. Spectral methods. Fourier analysis. Fourier series. Fourier transform. Discrete Fourier transform. Complex functions. Complex analysis. Potential flows. Analytical complex functions. Singularities. Random variables. Methods of mathematical statistics. Probability and probability density functions. Correlations and moments.

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.

lecture hours of active teaching: 35

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
Perturbation methods in fluid mechanics, Milton Van Dyke, THE PARABOLIC PRESS, Sranford, California, 1975., ISBN: 0-915760--01-0 Fractional Differential Equations (An Introduction to Fractional Derivatives, Fractional Differential Equations, Some Meth. of the Sol.), Igor Podlubny, Academic Press, San Diego-Boston-New York, 1999. Function of a Complex Variable, Theory and Technique, Carrier, G.F., M.Krook and C.E. Pearson, Mc Graw-Hill, 1966. New York

Measurement techniques in combustion

ID: PhD-3275
responsible/holder professor: Stojiljković D. Dragoslava
teaching professor/s: Jovanović V. Vladimir, Manić G. Nebojša, Stojiljković D. Dragoslava
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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.

lecture hours of active teaching: 35

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
Stephen R. Turns, An Introduction to Combustion: Concepts and Applications, 2 edition, McGraw-Hill, 2000
E.L. Upp, Paul J. LaNasa, Fluid Flow Measurement A Practical Guide to Accurate Flow Measurement, Second Edition, Gulf Professional Publishing, 2002

Measurements in hydro-energy systems

ID: PhD-3594
responsible/holder professor: Ilić B. Dejan
teaching professor/s: Ilić B. Dejan
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
ECTS credits: 5
final exam: seminar works

goals
The main aim of the course is to guide students in the field of complex measurements in hydro-energy systems (hydropower plants and pump systems), as well as in ventilation systems. Determination of characteristics of hydraulic turbines, pumps, and fans in the laboratory and in situ.

learning outcomes
Obtaining the knowledge of energy characteristics measurements of hydraulic turbines, pumps, and fans. Training in complex measurements in the laboratory and in situ according to relevant international standards.

theoretical teaching
Physical quantity measurements in hydro-energy and ventilation systems. Calibration of pressure, velocity and flow measuring devices. International Standards for field and model acceptance tests, for determination of the characteristics of the hydraulic turbines, pumps, pump-turbines and fans. Test installations and measurement methods. Energy and cavitation characteristics determination of hydraulic turbines, pumps and pump-turbines. Energy characteristics determination of industrial fans. Measurement uncertainty and uncertainty analysis.

practical teaching
Research in laboratory, in accordance with the selected research topic.

prerequisite
No prerequisites.

learning resources
[1] Hand-outs and relevant international standards.

[2] Experimental test rigs and equipment in the Laboratory.

lecture hours of active teaching: 35

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): 30

references
Ilić D. B., Ćantrak Đ. S. (2017): Manual for fluid flow measurements in laboratory, Fac. of Mechanical Eng. Univ. of Belgrade,Belgrade.

Mechanics of Ballistic Systems

ID: PhD-3620
responsible/holder professor: Jevtić T. Dejan
teaching professor/s: Jevtić T. Dejan, Micković M. Dejan
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Without special conditions.

learning resources

Design of Towed Artillery Weapon Systems, MIL-HDBK-785(AR), 1990.

Alferov V.V., Construction and Calculation of Automatic Weapons (in Russian),

Masinostroenie, Moskow, 1977.

Allsop D.F., Cannons, Brassey's, London, 1995.

lecture hours of active teaching: 35

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

Automatic Weapons - Engineering Design Handbook, US Army Materiel Command Pamphlet 706-260, 1970;

Mechanics of Bipedal Gait

ID: PhD-3124
responsible/holder professor: Lazarević P. Mihailo
teaching professor/s: Lazarević P. Mihailo
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
The basic concepts of anthropometry and elements of functional anatomy, biomechanics of human limbs and other functional parts of the human body. Biomechanical properties of bones, muscles, joints, tendons and ligaments. Biomechanics of the shoulder, elbow, hand, spine, hip, foot:rheological models. Statics of musculoskeletal system of humans. The concept of locomotion, types of locomotions.Kinematics of the human locomotor system (HLS) and motor tasks. The task of direct and inverse dynamics of HLS. Motion,the energy aspects of walking and running. Fundamentals of kinematic mechanisms. Model mechanism of HLS in the form of kinematic chains with branching-differential equations of motion (DIFE)-example of the upper body;example of closed kinematic chain: bipedal locomotion. Biomechanics of walking/bipedal locomotion. Orthopaedic biomechanics.

Strategy of walking -ZMP (zero moment point), CMP (the centroidal moment pivot). Modern "gait" laboratory and basic measurements.Walking-inverted pendulum model, running-mass model and springs. Orthopedic biomechanics with emphasis on bipedal movement.

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

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

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

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

[5]Christopher L V.,B.Davis, J.Connor, Dynamics of Human Gait, Kiboho Publishers ,South Africa,1999.

[6]Лазаревић М.Основе биомеханике,(скрипта у припреми),2011.

[7]Писани изводи са предавања(handouts),

[8] Cyberbotics Webots - софтверски пакет

[9]MATLAB,LegoMinstorm, софтверски пакети

lecture hours of active teaching: 35

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
Duane Knudson,Fundamentals of Biomechanics,Springer Science+Business Media, LLC,2007.
D. Schneck, J. Bronzino,Biomechanics : principles and applications, CRC PressLLC,2003.
Y. Hong and R. Bartlett,Routledge Handbook of Biomechanics and Human Movement Science,Routledge,2008
Y. Hong and R. Bartlett,Routledge Handbook of Biomechanics and Human Movement Science,Routledge,2008.
S. Cowin, S. B.Doty,Tissue Mechanics, Springer Science+Business Media, LLC,2007

Mechanics of locomotor system

ID: PhD-3120
responsible/holder professor: Lazarević P. Mihailo
teaching professor/s: Lazarević P. Mihailo
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
The basic concepts of anthropometry and elements of functional anatomy, biomechanics of human limbs and other functional parts of the human body. Biomechanical properties of bones, muscles, joints, tendons and ligaments. Biomechanics of the shoulder, elbow, hand, spine, hip, foot:rheological models. Statics of musculoskeletal system of humans. The concept of locomotion, types of locomotions.Kinematics of the human locomotor system (HLS) and motor tasks. The task of direct and inverse dynamics of HLS. Motion,the energy aspects of: work, energy, power. Biomechanics of internal organs and organ systems.Basic concepts of tissue biomechanics. Fundamentals of kinematic mechanisms. Model mechanism of HLS in the form of kinematic chains with branching-differential equations of motion (DIFE)-example of the upper body;example of closed kinematic chain: bipedal locomotion. Biomechanics of walking/bipedal locomotion. Orthopaedic biomechanics.

practical teaching
Examples of determining anthropometric data. Models of muscle: skeletal,smooth, cardiac, bone models, the spinal column. Examples of solving the problems of kinematics and dynamics of the HLS. Energy analysis and stress analysis: various examples. Example of the cardiovascular, nervous and respiratory systems. Examples of biomechanical models of organs. Instances of models of HLS in the form of kinematic chains-different cases. Mathematical modeling of human body motion and interaction with the environment. Examples of locomotor motion: walking, running, sports movements. Computer methods and techniquesin biomechanics (FEM, Matlab,...) with the appropriate application. Biomedical measurements, instrumentation and equipment. Examples of models of prosthetic/ orthotic mechanisms of-applications in rehabilitation. Various problems of HLS.

prerequisite
none

learning resources

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

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

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

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

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

[6] Written abstracts from the lectures (Handouts)

[7] Cyberbotics Webots - software simulation package

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

lecture hours of active teaching: 35

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

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

Mechanics of Nonholonomic Systems

ID: PhD-3561
responsible/holder professor: Radulović D. Radoslav
teaching professor/s: Radulović D. Radoslav
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Basic concepts: analytical definitions of constraints, possible displacements, similarity of variational and differential operations. Differential equations of motion of non-holonomic systems with linear non-holonomic constraints of first order: equations of motion forming by means of Lagrange-D'Alembert's principle, equations of motion in quasi-coordinates, determination of reactions of constraints. First integrals of equations of motion of non-holonomic systems: linear and quadratic integrals, integral of energy, generalized integrals of energy, cyclic integrals. Variational principles in mechanics of non-holonomic systems: Hamilton-Ostrogradsky's principle, Gauss' principle, Hertz's principle,. Stability of motion of non-holonomic systems: equilibrium, stability of steady motions. Non-holonomic systems having constraints of general kind: equations of motion having constraints of general kind. Technical problems of stability of systems with rolling: theory of motion of elastic pneumatic tire.

practical teaching
Basic concepts: analytical definitions of constraints, possible displacements, similarity of variational and differential operations. Differential equations of motion of non-holonomic systems with linear non-holonomic constraints of first order: equations of motion forming by means of Lagrange-D'Alembert's principle, equations of motion in quasi-coordinates, determination of reactions of constraints. First integrals of equations of motion of non-holonomic systems: linear and quadratic integrals, integral of energy, generalized integrals of energy, cyclic integrals. Variational principles in mechanics of non-holonomic systems: Hamilton-Ostrogradsky's principle, Gauss' principle, Hertz's principle,. Stability of motion of non-holonomic systems: equilibrium, stability of steady motions. Non-holonomic systems having constraints of general kind: equations of motion having constraints of general kind. Technical problems of stability of systems with rolling: theory of motion of elastic pneumatic tire.

prerequisite
Defined by the curriculum study of Phd studies program.

learning resources
Andjelic T., Stojanovic R.; Rational Mechanics, Belgrade, 1965.

Dobronravoff V.; Principles of Mechanics of Non-holonomic Systems, Nauka, Moscow, 1970.

Pars L.; Treatise on Analytical Dynamics, Nauka, Moscow, 1971.

lecture hours of active teaching: 35

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

Andjelic T., Stojanovic R.; Rational Mechanics, Belgrade, 1965.
Dobronravoff V.; Principles of Mechanics of Non-holonomic Systems, Nauka, Moscow, 1970.
Pars L.; Treatise on Analytical Dynamics, Nauka, Moscow, 1971.

Mechanics of Variable Mass Systems

ID: PhD-3094
responsible/holder professor: Jeremić M. Olivera
teaching professor/s: Jeremić M. Olivera
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Differential equation of motion of a particle having variable mass – Meshchersky's equation. Two Tsiolkovsky's problems. Motion of a particle having variable mass in a resisting medium. Inverse tasks of a particle having variable mass. Examples. Basic laws of dynamics of a body having variable mass. Differential equations of motion of a body having variable mass in Lagrangian (generalized) coordinates. Canonical form of equations of motion of a body having variable mass. Variational problems of a particle having variable mass.

practical teaching
Differential equation of motion of a particle having variable mass – Meshchersky's equation. Two Tsiolkovsky's problems. Motion of a particle having variable mass in a resisting medium. Inverse tasks of a particle having variable mass. Examples. Basic laws of dynamics of a body having variable mass. Differential equations of motion of a body having variable mass in Lagrangian (generalized) coordinates. Canonical form of equations of motion of a body having variable mass. Variational problems of a particle having variable mass.

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)

lecture hours of active teaching: 35

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

Komsodemjanskij A.; Course of Theoretical Mechanics, Part 2., Prosceshcheije, Moscow, 1966.
Gurin A.; Principles of Mechanics of bodies having variable mass and Dynamics of Rockets, Part 1., MGPI, Moscow, 1960.
Trivunac, J., Basic in Dynamics of Reactive Systems, Institut za prostornu tehniku, Beograd, 1968. 18.2

Mechatronic systems design

ID: PhD-3604
responsible/holder professor: Veg A. Emil
teaching professor/s: Veg A. Emil, Šiniković B. Goran
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
ECTS credits: 5
final exam: written

goals
Mastering the knowledge fund required for competent synthesis of the structure of the mechatronic system, defining the executive mechanism, control module and algorithm. Developing a creative ability to set an ideological and operational mechatronic solution for a given problem, which will optimally satisfy the defined technical requirements.

learning outcomes
Possession of engineering abilities to perform quality synthesis of electronic and processor module mechanisms as key subassemblies of mechatronic solution. Precise solution of a direct engineering task, synthesis of an original mechatronic solution, with integration of specific modules and elements.

theoretical teaching
Design in mechatronics; Initial vision of the concept of mechatronic solution, Mechanisms in mechatronics; The science of the theory of machines and mechanisms. Classification of Mechanisms, Measurements in Mechatronics 1; Analog and digital sensors, Measurements in mechatronics 2; Definition of light photodiodes and phototransistors, Actuators in mechatronics; Linear and rotating actuators, Actuators with motion transformation, Digital and analog electronic modules; Logic circuits and applications, Condition detection (0,1), Control concepts in Mechatronics; Processor system structure, System programming; Software tools available, Input port programming, Output port programming.

practical teaching
Overview of typical mechatronic solutions; Turbocharger with variable geometry, Decomposition of mechatronic solution; Analysis of elements, functions and signals of the sensor block, Elementary mechanisms; Examples of different configurations of mechanisms for performing certain motion profiles, Sensors 1; Measurement of analog quantities using PC platform and Lab View software package, Sensors 2; Elaboration of an idea for solving a user's numerical-graphic display of results, Actuators; Electric motor drive controlled by frequency regulator; Operational amplifier, PC platform operation, PIC platform operation;

prerequisite
None.

learning resources
Mechanism models (articulated quadrangle, piston mechanism) Sensor set (thermocouples, inductive accelerometers, opto sensors). Development system DC PIC Pneumatic components (cylinders, valves, PLC)

lecture hours of active teaching: 35

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): 35

references

Mechatronics Systems and Adaptronics

ID: PhD-3208
responsible/holder professor: Petrović B. Petar
teaching professor/s: Petrović B. Petar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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 simultaeously 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.

lecture hours of active teaching: 35

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

Bolton, W., Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering, Prentice Hall, 2004, ISBN-10: 0131216333.
H. Janocha, Adaptronics and Smart Structures: Basics, Materials, Design, and Applications, Springer, 1999, ISBN: 3540614842.
N. M. White, P. Boltryk, W. R. Habel, R. Petricevic, M. Gurka, Adaptronics and Smart Structures: Sensors in Adaptronics, Springer-Verlag, 2007, ISBN 978-3-540-71965-6.
V.N. Vapnik, The Nature of Statistical Learning Theory, Springer Verlag, 2 edition (November 19, 1999), ISBN-10: 0387987800.
B. Kosko, Neural Networks and Fuzzy Systems: A Dynamical Systems Approach to Machine Intelligence, Prentice Hall; June 1991, ISBN-10: 0136114350.

Methods of Energy Planning

ID: PhD-3528
responsible/holder professor: Stevanović D. Vladimir
teaching professor/s: Stevanović D. Vladimir
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Energy flows and structure of energy consumption in the world and certain states and regions. Classification of energy and energy indicators. Energy consumption versus economy development. Energy efficiency. Economical methods for the evaluation of energy investments. Renewable energy usage and new energy sources and technologies. Accumulation of energy. Methods for the modelling of energy systems. Energy planning. Energy legislation. Energy consumption and environmental protection.

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.

lecture hours of active teaching: 35

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
Kleinpeter, M., Energy Planning and Policy, John Wiley & Sons, New York, 1995.
Bakshi, B.R. et al., Thermodynamics and the Destruction of Resources, Cambridge University Press, Cambridge, 2011.
Guidelines on Strategic Planning and Management of the Energy Sector, United Nations, New York, 2002.
Energy - The International Journal, Elsevier, http://www.sciencedirect.com/science/journal/03605442
Chateau, B., Lapillonne, B., Energy Demand: Facts and Trends, Springer, 1982.

Microchannel fluid flow

ID: PhD-3267
responsible/holder professor: Stevanović D. Nevena
teaching professor/s: Milićev S. Snežana, Stevanović D. Nevena
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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 microsistems 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.

lecture hours of active teaching: 35

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

Karniadakis G., Beskok A., Aluru N., Microflows and Nanoflows Fundamental and Simulations, Springer, 2005
Bruus H., Theoretical Microfluidics, Oxford University Press, 2008.
Kirby, B., Micro and Nanoscale Transport in Microfluid Devices, Cambridge University Press, 2010.
Dongqing L., Encyclopedia of Microfluidics and Nanofluidics, Springer, 2008.
Stevanović,N.,Fluid flows in microdevices, Faculty of Mechanical Engineering, Belgrede,2010.

Missile Guidance control systems

ID: PhD-3598
responsible/holder professor: Todić N. Ivana
teaching professor/s: Todić N. Ivana
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
ECTS credits: 5
final exam: written

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:

Presentation and comparison of basic guidance laws (proportional navigation, constant bearing and line-of-sight guidance) in terms of principal information required for realization and demands for guidance. Midcourse and terminal guidance. Basic components of missile. The application of gimbaled and strapdown seeker during terminal guidance. Comparison of classical and modern guidance and control. Definition of Lambert's problem in flight mechanics of guided weapons. Optimal guidance based on linear-quadratic differential games. Mathematical background for noise analysis. Digital fading memory noise filters in homing loops. Estimation theory applied to guidance loop. Other forms of tactical guidance. Basic flight mechanics for tactical and strategic missile. Lambert guidance. Guidance technique and numerical examples for solving Lambert guidance. Modifications of Lambert.

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

prerequisite
none

learning resources
P. Garnel: Guided Weapon Control System, Pergamon Press, New York, 1980.

lecture hours of active teaching: 35

assessment of knowledge (maximum number of points - 100)

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

references
Siouris, G.M., “Missile Guidance and Control Systems”, Springer, ISBN 0-387-00726-1, 2004
Boiffier, J.L., “The Dynamic of Flight The Equations”, John Wiley & Sons Ltd. England, ISBN 0-471-94237-5, 1998

Titterton, D.H. and Weston, J.L., ”Strapdown Inertial Navigation Technology – 2nd edition”, 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 and Position Algorithms”, Journal of Guidance, Control, and Dynamics, Vol. 21, No. 2, pp. 208-221
Landau, I.D., Lozano, R., M’Saad, M., Karimi, A., “Adaptive Control Algorithms, Analysis and Applications”, Springer, ISBN 978-0-85729-663-4, 2011

Model and prototype testing of hydraulic machinery

ID: PhD-3438
responsible/holder professor: Božić O. Ivan
teaching professor/s: Božić O. Ivan
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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.

lecture hours of active teaching: 35

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

Miroslav Benišek „Hidraulične turbine“, Mašinski fakultet u Beogradu, 1998
Ivan O. Božić „Hidraulične turbine - Praktični primeri sa izvodima iz teorije“, Mašinski fakultet u Beogradu, 2017

Modeling of Turbulent Flows

ID: PhD-3501
responsible/holder professor: Ćoćić S. Aleksandar
teaching professor/s: Ćoćić S. Aleksandar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Introduction to turbulence modelling and simulations. Direct numerical simulations of homogenous and inhomogenous turbulence. Turbulent viscosity. Turbulence models based on turbulent viscosity (RANS models). Algebraic models. Models based on turbulent kinetic energy. One-equation and two-equation models. Full stress closure. Redistribution tensor. Returning to isotropy models. Anisotropy of turbulent stress tensor. No-nlinear forms of return-to-isotropy model. Rapid distortion theory. Basic LRR-IP model. Advanced models for redistribution tensor. Wall effects. Fluctuating pressure and disipation of turbulent kinetic energy near the wall. Wall functions. Turbulent models based on elliptic relaxation. Algebraic models based on non-linear turbulent viscosity. Large eddy simulation (LES) approach. Filtering. Filtered equations of motions. Basic models in LES: Smagorinsky and dynamic Smagorisky models. Imlicit LES. Wall effects in LES.

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.

lecture hours of active teaching: 35

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
Pope, S.P. : Turbulent Flows, Cambridge University Press, 2011
Durbin P.A., Petterson Reif B.A.: Statistical Theory and Modeling for Turbulent Flows, Wiley, 2011

Wilcox, D.: Turbulence Modeling for CFD, DCW Industries Inc., 2006
Launder, B.E., Sandham N.D. (editors): Closure Strategies for Turbulent and Transitional Flows, Cambridge University Press, 2002

Modelling of Composite Material Micromechanics

ID: PhD-3515
responsible/holder professor: Balać M. Igor
teaching professor/s: Balać M. Igor
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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.

3. Numerical models for various distribution of reinforcement – 2D and 3D (SC distribution and FCC distribution), Semi-empirical models.

4. Various micromechanics models for elastic moduli: Longitudinal Young modulus. Transverse Young modulus. In plane shear modulus. Poissons ratio.

5. Micromechanics models for strength: Strength of unidirectional composites. Longitudinal strength, fiber and matrix failure mode. Transverse strength. In plane shear strength.

6. Analysis of particulate reinforced composites: Influence of volume fraction, distribution and shape of particles on elastic constants and strength. Porous and nonporous matrix.

practical teaching

-

prerequisite

Taken exams:

Strength of materials,

The base of strenght 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.

lecture hours of active teaching: 35

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
responsible/holder professor: Stevanović D. Vladimir
teaching professor/s: Stevanović D. Vladimir
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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 maser or doctoral studies.

learning resources
Course handouts.

Stevanović, V., Thermal-Hydraulics of Steam Generators – Modelling and Numerical Simulation, Monograph, Faculty of Mechanical Engineering, Belgrade, 2006.

Computer equipment.

Software for numerical solving of systems of differential equations of various types.

Software for simulation and analyses of pressure transients in pipeline networks and pressurized vessels.

Software for simulation and analyses of multidimensional two-phase flows.

lecture hours of active teaching: 35

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

Versteeg, H.K., Malalasekera, W., An introduction to Computational Fluid Dynamics, Longman Group Ltd., Harlow, 1995.
Wulff, W., Computational methods for multiphase flow, Multiphase Science and Technology, Vol. 5, Begell House, 1990.
Streeter, V.L., Wylie, E.B., Hydraulic Transients, McGraw Hill, New York, 1967.
C., Anderson, D.A., Pletcher, R.H., Computational Fluid Mechanics and Heat Transfer, Taylor&Francis, New York, 1997.
Stevanovic, V., Thermal-Hydraulics of Steam Generators – Modelling and Numerical Simulation, University of Belgrade, Faculty of Mechanical Engineering, 2006.

Modelling, optimisation and forecasting in Industrial engineering

ID: PhD-3022
responsible/holder professor: Bugarić S. Uglješa
teaching professor/s: Bugarić S. Uglješa, Veljković A. Zorica, Petrović B. Dušan
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
1. Bugaric, U., Petrovic, D.: Servicing system modelling, Faculty of Mechanical engineering Belgrade, Belgrade, 2011.

2. Bugaric, U.: Methodology for analysis of single position machines work, Foundation Andrejevic, Belgrade, 2003.

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

4. Software: QSopt Version 1.0 (Linear programming problems).

5. Software: IOR Tutorial (Interactive Operations Research).

6. Software: MS – Project (Project management).

7. Personal computers.

lecture hours of active teaching: 35

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

Petrić, J.: Operations Research (book 1 & 2), Savremena administracija, Belgrade, 1990.
Churchman, C. W., Ackoff, R. L., Arnoff, E. L.: Introduction to Operations research, John Willey & Sons Inc., 1957.
Hillier, F. S., Lieberman, G. J.: Introduction to operations research (seventh edition), McGraw-Hill, New York, 2000.

Modern Combustion Appliances

ID: PhD-3318
responsible/holder professor: Adžić M. Miroljub
teaching professor/s: Adžić M. Miroljub, Milivojević M. Aleksandar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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.
6. Solid matrix combustion.
7. Flameless combustion.
8. Preparation of fuels.
9. Combustion of non-standard fuels.
10. Modern combustion equipment.
11. Combustion and environmental protection.
12. Optimization of combustion equipment.

practical teaching
n/a

prerequisite
No preconditions for attendance

learning resources
lecture hours of active teaching: 35

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
Warnatz J., Mass U., Dibble R. Combustion, 2006.

Modern concepts of organizations

ID: PhD-3152
responsible/holder professor: Milanović D. Dragan
teaching professor/s: Milanović D. Dragan, Spasojević-Brkić K. Vesna
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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. Use of OrgCon software package in diagnosis of organization 6. Donaldson's non-contingency theory 7. Types of organizational structures in modern theory of organization 8. Organizational change. Diagnosis and management of organizational change. A case-study example of analyzing the state of organization in a specific company 9. The possibility of implementation of modern concepts of organization in companies 10. Open issues and directions of further development of modern concepts of organizations

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
lecture hours of active teaching: 35

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

Mintzberg, H., Structure in Five - Designing Effective Organizations, Prentice Hall, Englewood Clifs, New York, 1983.

Mintzberg, H., The Structuring of Organizations, Prentice Hall Englewood Cliffs, New York, 1979.

Moore, B., Brown, A, The Application of TQM: organic or mechanistic, International Journal of Quality and Reliability, Vol. 23, No. 7, pp. 721-742, 2006.

Khandwalla, N.P. The Design of Organization, Harcourt Brace Jovanovic, New York, 1977.

Burton, R., Obel, B., Fit and Misfits in the Multi-Dimensional Contigency Model: An Organizatiional Change Perspective, LOK Center, Danish Social Science Research Council, 2000.

Multiphase flows D

ID: PhD-3619
responsible/holder professor: Lečić R. Milan
teaching professor/s: Lečić R. Milan, Ćoćić S. Aleksandar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
ECTS credits: 5
final exam: written

goals
To get familiar with different types of multiphase flows. Acquaintance with the possibilities of theoretical analysis and experimental methods when studying numerous problems of multiphase flows.

learning outcomes
Acquiring skills and mastering theoretical and numerical methods needed to analyze different types of multiphase flows.

theoretical teaching
Concept and types of multiphase flows. Basic terminology in multiphase flows. Basic equations for multiphase flows: equation of continuity, momentum equation, energy equation and equation of diffusion. Eulerian and Lagrangian approach to the study of multiphase flows, equations for the Euler-Euler model and Euler-Lagrange model. Analysis of forces acting on the gas bubble and/or solid particle-apparent force, Basset force, Safman forces, etc. Stokes solution for laminar flow around a sphere. Non-stationary flow around a spherical particle. Characteristic velocities: fluid flow, deposition, sound, erosion, and critical velocity. Fluidization. Calculation of flow of incompressible and compressible fluidized bed without and with matter and energy exchange. Pneumatic transport. Application and calculation methods of pneumatic transport. Hydraulic transport. Suspension rheology. Laminar suspension flow. Liquid-gas two-phase flow: flow modes and maps in horizontal and vertical tubes. Calculation of bubble motion through a fluid. Two-phase streams with separation surface. Cavitation, evaporation, condensation. Two-phase flow in heat exchange tubes. Numerical methods for multiphase flow calculation in OpenFOAM. Experimental methods for studying multiphase flows.

practical teaching
- Fluidization laboratory exercise. - CFD simulation of multiphase flow.

prerequisite
No special conditions.

learning resources
-

lecture hours of active teaching: 35

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
Multiphase flows with droplets and particles. Crowe et al. CRC Press, 2012.
Essentials of fluidization technology, Grace et al. , Wiley-Ch, 2020

Nanomechanical Characterization of Materials

ID: PhD-3513
responsible/holder professor: Balać M. Igor
teaching professor/s: Balać M. Igor
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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.

5. Indentation size effect: theory of Nix and Gao.

6. The role of grain boundaries and interfaces.

7. Nanoindentation with ultralow forces; nanoindenting with Atomic Fore Microsope - AFM.

8. Applications.

practical teaching
1. Introducing Hysitron nanoindenter.

2. Machine compliance.

3. Sample preparation.

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.

lecture hours of active teaching: 35

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
responsible/holder professor: Jovanović Ž. Radiša
teaching professor/s: Jovanović Ž. Radiša
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
On successful completion of the course the students should be able to:

• Understand fundament theories, learning methods and advanced issues of neural network and fuzzy systems.

• Apply the learned knowledge of neural and fuzzy systems to solve various research problems.

theoretical teaching
Introduction to artificial neural networks. Feedforward neural networks. Recurrent and Hopfield neural networks. Radial basis function neural network. Support vector machines. Self-organizing map neural network. Applications of neural network. Fundamentals of fuzzy logic and fuzzy systems. Takagi-Sugeno fuzzy modeling and identification. Stability analysis of fuzzy systems. Applications of fuzzy systems.

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.

• Intelligent Control Systems Laboratory, Control Systems Laboratory.

lecture hours of active teaching: 35

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

Simon Haykin, "Neural Networks and Learning Machines", Vol. 3. Upper Saddle River, NJ, USA:: Pearson, 2009.
K. M. Passino, S. Yurkovich, "Fuzzy Control", Addison-Wesley, 1998.

Non linear Finite Element Methods

ID: PhD-3511
responsible/holder professor: Buljak V. Vladimir
teaching professor/s: Buljak V. Vladimir
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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 FOTRAN 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

1.Non-linear finite element analysis of solids and structures – Volume 1. M.A. Crisfield

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

3.An introduction to Nonlinear Finite Element Analysis. J.N Reddy

4.Computational methods in plasticity: Theory and applications. EA de Souza Neto, D. Peric and DRJ Owen.

lecture hours of active teaching: 35

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
responsible/holder professor: Milković D. Dragan
teaching professor/s: Milković D. Dragan
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
ECTS credits: 5
final exam: seminar works

goals
1. Deepening of knowledge in different areas of нon-linear strenght problems of rail vehicles.

2. Become acquainted with advanced methods and tools for the study of нon-linear strenght problems of rail vehicles.

3. Training for participation in research and development teams on the projects оф 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.

2. Analyze specific non-linear strength phenomena of rail 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 absorbtion 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

lecture hours of active teaching: 35

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
responsible/holder professor: Kostić A. Ivan
teaching professor/s: Kostić A. Ivan
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Types and characteristics of lifting surfaces. Planar and nonplanar lifting surfaces. Mathematical modeling of lifting surfaces. Biplane and multiple wing designs. Winglets and wingtip devices. Witcomb winglets, blended, elliptical and spiroid winglets. Tip fences, tip sails, vortex diffusers. Wing-grid tips. Split wingtips. C-wing concept. Boxplanes, joined wings, lifting struts. Ring wings. Hyperelliptic wings. Grid fins. CDF modeling and analysis of nonplanar lifting surfaces.

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.

lecture hours of active teaching: 35

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

I. Kostić, Z. Stefanović: Nonplanar Lifting Surfaces - handouts, University of Belgrade, Faculty of Mechanical Engineeering, Belgrade, 2012.
I. Kroo: Nonplanar Wing Concepts for Increased Aircraft Efficiency, von Karman Institute lecture series on Innovative Configurations and Advanced Concepts for Future Civil Aircraft, 2005.
J. Katz, A. Plotkin: Low Speed Aerodynamics from Wing Theory to Panel Method, McGraw-Hill Co., Singapore, 1991.
S. M. Belotserkovskii: The Theory of Thin Wings in Subsonic Flow, Plenum Press, New York, 1967.

Nuclear Power Plants Safety

ID: PhD-3526
responsible/holder professor: Stevanović D. Vladimir
teaching professor/s: Stevanović D. Vladimir
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
ECTS credits: 5
final exam: seminar works

goals
Simulation and analyses of nuclear power plant transients and accidents that might lead to or results into jeopardizing plant safety and environment, such as smal 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
Nuclear reactor steady state and transient operation. Coupling of thermal-hydraulic and neutron kinetics. Thermal feedback mechanisms. Sources and intensity of disturbances. Active and passive safety systems. Thermal-hydraulic models and computer codes. Safety analyses and risk studies.

practical teaching
Development of a thermalhydraulic 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.

lecture hours of active teaching: 35

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
Klimov, A., Nuclear Physics and Nuclear Reactors, Mir Publishers, Moscow, 1981.
Knief, R.A., Nuclear Energy Technology, Hemisphere, 1981.
Kolev, N.I., Nuclear Thermal Hydraulics, Springer, 2015.

Stevanovic, V., Thermal-Hydraulics of Steam Generators – Modelling and Numerical Simulation, University of Belgrade, Faculty of Mechanical Engineering, 2006.
Safety of Nuclear Power Plants: Design, International Atomic Agency, Vienna, 2012.

Numerical methods

ID: PhD-3259
responsible/holder professor: Spalević M. Miodrag
teaching professor/s: Spalević M. Miodrag, Cvetković S. Aleksandar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Elements of the errors theory. IEEE-754-2008. Classes singe and double in Matlab. Machine precision. Errors of approximate values of functions. Inverse problem for error. Condition of problem. Interpolation, Lagrange and Newton interpolation polynomials. Matlab function interp1. Numerical differentiation. Matlab function diff. Numerical methods for solving of nonlinear equations and systems. Interpolation quadrature formulas. Matlab functions integral, trapz. Methods of error estimation. Generalization to multiple integrals. Construction of Gauss formulas from Jacobi matrix by QR algorithm. Modification of Gauss formulas. Radau and Lobatto quadratures. Kronrod schemes. Gauss-Turán quadratures and generalizations. Convergence of quadrature processes. Formulas of trigonometric type. Integration of fast oscillating functions. Interpolating cubature formulas. Review of cubature formulas for some specific areas and certain weight functions. Numerical linear algebra. Gassuian elimination. LU factorization. Perturbation analysis. Iterative methods. Functions linsolve, lu in Matlab. Approximation theory. Bernstein theorem. Least squares approximation. Discrete least squares approximation. Chebyshev mini-max approximation. Implementation of linear and nonlinear regression in Matlab. ODE. Cauchy problem. Euler methos. Convergence analysis. Crank-Nickolson method. Zero stability. Stability on unbounded intervals. Higher order methods. Predictor-corrector methods. Systems of ODE. Runge-Kutta methods. ODE functions family in Matlab. PDE. Classification. Elliptic equations. Variational formulation of the Dirichet problem. Neuman problem. Finite difference method. Finite element method. Eigen value problem for elliptic operator. Parabolic equations. Variational formulation. Hyperbolic equations. Finite difference methods. Finite element methods. PDE toolbox in Matlab.

practical teaching

Elements of the errors theory. IEEE-754-2008. Classes singe and double in Matlab. Machine precision. Errors of approximate values of functions. Inverse problem for error. Condition of problem. Interpolation, Lagrange and Newton interpolation polynomials. Matlab function interp1. Numerical differentiation. Matlab function diff. Numerical methods for solving of nonlinear equations and systems. Interpolation quadrature formulas. Matlab functions integral, trapz. Methods of error estimation. Generalization to multiple integrals. Construction of Gauss formulas from Jacobi matrix by QR algorithm. Modification of Gauss formulas. Radau and Lobatto quadratures. Kronrod schemes. Gauss-Turán quadratures and generalizations. Convergence of quadrature processes. Formulas of trigonometric type. Integration of fast oscillating functions. Interpolating cubature formulas. Review of cubature formulas for some specific areas and certain weight functions. Numerical linear algebra. Gassuian elimination. LU factorization. Perturbation analysis. Iterative methods. Functions linsolve, lu in Matlab. Approximation theory. Bernstein theorem. Least squares approximation. Discrete least squares approximation. Chebyshev mini-max approximation. Implementation of linear and nonlinear regression in Matlab. ODE. Cauchy problem. Euler methos. Convergence analysis. Crank-Nickolson method. Zero stability. Stability on unbounded intervals. Higher order methods. Predictor-corrector methods. Systems of ODE. Runge-Kutta methods. ODE functions family in Matlab. PDE. Classification. Elliptic equations. Variational formulation of the Dirichet problem. Neuman problem. Finite difference method. Finite element method. Eigen value problem for elliptic operator. Parabolic equations. Variational formulation. Hyperbolic equations. Finite difference methods. Finite element methods. PDE toolbox in Matlab.

prerequisite

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

learning resources

1. M.M. Spalević, M.S. Pranić, Numerical methods, Skver, Kragujevac, 2007

(http://mat.mas.bg.ac.rs)

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

4. B.S. Jovanović: Numerical methods for solving PDE, Math. Institute, Beograd 1989, pgs. 130

5. G. Mastroianni, G.V. Milovanović: Interpolation Processes - Basic Theory and Applications, Springer Monographs in Mathematics, Springer – Verlag, Berlin – Heidelberg, 2008, XIV+444 pp.

6. W. Gautschi, Orthogonal Polynomials: Computation and Approximation, Oxford University Press, Oxford, 2004

7. W. Gautschi, Numerical Analysis: An Introduction, Birkhäuser, Boston, 1997

8. A. Quarteroni, F. Saleri, Scientific Computing with MATLAB, Springer, 2003.

9. S. Larsson, V. Thomee, Partial Differential with Numerical Methods, Springer, 2005

10. Software Matlab

11. Software Mathematica

12. A.S. Cvetković, M.M. Spalević, Numerical methods, University of Belgrade, 2013

lecture hours of active teaching: 35

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

G. Mastroianni, G.V. Milovanović: Interpolation Processes - Basic Theory and Applications, Springer Monographs in Mathematics, Springer – Verlag, Berlin – Heidelberg, 2008, XIV+444 pp.
W. Gautschi, Orthogonal Polynomials: Computation and Approximation, Oxford University Press, Oxford, 2004
W. Gautschi, Numerical Analysis: An Introduction, Birkhäuser, Boston, 1997
A. Quarteroni, F. Saleri, Scientific Computing with MATLAB, Springer, 2003
S. Larsson, V. Thomee, Partial Differential with Numerical Methods, Springer, 2005

Numerical Methods in Ship Hydrodynamics

ID: PhD-3459
responsible/holder professor: Simić P. Aleksandar
teaching professor/s: Simić P. Aleksandar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
ECTS credits: 5
final exam: seminar works

goals
The application and development of numerical methods for the solution of various problems in ship hydrodynamics.

learning outcomes
Student should be capable of:

1) conducting calculations and solving various problems in ship hydrodynamics using numerical methods.

2) developing of new numerical methods, based on results of experimental investigation of hydrodynamic performances of ships.

theoretical teaching
Contemporary numerical methods in ship hydrodynamics. Available engineering tools for development of new methods.

practical teaching
Development and application of numerical methods in ship hydrodynamics in deep and restricted/shallow water, for determination of: ship resistance, ship-propeller-rudder interactions, external influences, etc.

prerequisite
Defined by the curriculum of studies.

learning resources
Internet resources, books, scientific journals, commercial software in the field.

lecture hours of active teaching: 35

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
Rojas, R.: Neural Networks – A Systematic Introduction, Springer-Verlag, Berlin, 1996
H. Schneeklnth and V. Bertram, Ship Design for Efficiency and Economy, 1998.
...

Numerical simulation of IC Engines processes - Advanced approach

ID: PhD-3421
responsible/holder professor: Popović J. Slobodan
teaching professor/s: Popović J. Slobodan
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Understanding the reality and complexity of Heat Engines working cycles. Capabilities to design complex models and sub-models structures using multidisciplinary approach. Capabilities to analyse engine processes and performance using advanced simulation models. Establishing the Cause & Effect relationship between working cycle and engine performance.

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.

3. Modeling of gas flow through the restriction points (intake and exhaust valves, crevices) based on isentropic flow of compressible fluid. Analytical and experimental determination of flow coefficients.

4. Modeling of heat transfer to cylinder walls. Theoretical fundamentals and practical equations for the evaluation of heat transfer coefficient.

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".

6. Specific problems of numerical solutions of model differential equations.

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)

lecture hours of active teaching: 35

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

J. Heywood: Internal combustion engines fundamentals, McGraw-Hill 1988, ISBN 9780-070-28637-5
F. Pischinger: Verbrennungskraftmaschinen Thermodynamic, Springer Verlag, ISBN
G. P. Merker et. al.: Simulating combustion and pollutant formation for engine development, Springer Verlag, ISBN 10 3-540-25161-8, 13 978-3-540-25161-3
R. Benson: The Thermodynamics and Gas Dynamics of Internal Combustion Engines, Vol 1, Vol. 2, Clarendon Press, Oxford, 1982, ISBN 0-19-856210-1
R Jankov: Diesel engine gas-thermodynamic processes and performance modelling (in Serbian), Naučna knjiga, Beograd, 1984

Numerical simulation of welding processes

ID: PhD-3609
responsible/holder professor: Popović D. Olivera
teaching professor/s: Popović D. Olivera, Sedmak S. Aleksandar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Defining the prior specification of welding technology (PSWT). Qualification of welding technology (QWT). Specification of welding technology (SWT).Heat treatment after welding. Welding sequence. Solving nonlinear problems by FEM; types of nonlinearities, review. Introduction to non-linear materials, the basic theory of plasticity. Presenting various criteria of plastic flow of material in the FEM. Connections between strains and stresses in the plastic field - and the flow law in the FEM formulation. Influence of reinforcement material. The influence of material anisotropy. The case of heterogeneous materials - application of welded joints. Problems porous materials. Viscoplasticity. Algorithms solving nonlinear problems; incremental - iterative procedures. Viscoelasticity. Presentation of thermal stress, coupled by FEM analysis. Application of different welding processes. The techniques of introducing residual stress.

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 algorithms solving nonlinear problems, convergence and accuracy of the solution. Developments of FEM contact models. Post-processing. Techniques of introducing residual stresses - application on different welding procedures. FEM solutions in assessing fracture integrity of the weld. Numerical simulation of welding processes.

prerequisite
-

learning resources

[1] Written lessons from lectures (handouts)

[2] A. Sedmak, Use of the fracture mechanics on the structure integrity assessment, Faculty of Mechanical Engineering, Belgrade, 2003.

[3] M. Kojic, Computational Prrocedures in Inelastic Analysis of Solids and Structures, Kragujevac, 1997.

[4] M. Sekulović, Finite Element Method, Faculty of Civil Engineering, Belgrade, 1988.

[5] S. Sedmak et al., The Challenge od Materials and Weldments, SSIL, Belgrade, 2008.

[6] AWS, Welding handbook, 9th edition

[7] S. Sedmak, A. Sedmak, Experimental and numerical methods of fracture mechanics in structural integrity assesment, TMF, Belgrade, 2000.

lecture hours of active teaching: 35

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

Kojic M., Computational Prrocedures in Inelastic Analysis of Solids and Structures, Kragujevac, 1997.
R.W.Hertzberg, Deformation and Fracture Mechanics of Engineering Materials, New York, 1996.
L. Pook, Metal Fatigue What It Is, Why It Matters, London, Springer, 2007.

Numerical Structural Analysis

ID: PhD-3255
responsible/holder professor: Simonović M. Aleksandar
teaching professor/s: Dinulović R. Mirko, Simonović M. Aleksandar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Principles, equations and nomenclature. Equations of elasticity, elastoplastic materials, viscoplastic materials. Lattice structures and elements. Line elements, curvature beam elements. Plates and Shells. Volume problems. Linear dynamic and stability. Forced vibration of linear systems. Semianalytic methods. Applying Finite element Method for specific problem solving. Nonlinear problems. Finite element discretisation of nonlinear structures. Numerical methods of linear system equation solving. Adaptive techniques.

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

lecture hours of active teaching: 35

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.
A.V. Perelmuter, V.I. Slivker, Numerical Structural Analysis - Methods, models and pitfalls, - Springer 2003.
Z.Bittnar, J.Sejnoha., Numerical Methods in Structural Mechanics, -Tomas Telfold 1996.
M. Sathyamoorthy, Nonlinear Analysis of Structures, - CRC Press 1998.

Operating Systems in Mechatronics

ID: PhD-3224
responsible/holder professor: Radojević L. Slobodan
teaching professor/s: Bengin Č. Aleksandar, Mitrović B. Časlav, Radojević Lj. Slobodan
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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.
3. Classic Round Robin - RR algorithm.
4. Non-classical RR algorithm.
5. Processes with urgent priorities in the non-classical RR algorithm.
6. Processes with highest priorities in the non-classical RR algorithm.
7. Standard priority processes in 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.

lecture hours of active teaching: 35

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
responsible/holder professor: Obradović M. Aleksandar
teaching professor/s: Obradović M. Aleksandar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Classic extremal problems in mechanics. Control in mechanical systems. The goal of motion control. Objective function. Optimal control. The differential equations of controlled mechanical system. Maximum principle. Transversality conditions. Limited control. Mechanical systems wuth limited phase state. Singular control. Examples of singular control. Parameter optimization. Motion control of rigid bodies. Examples of optimal control of rigid body systems motion. Optimal stabilization of motion of the mechanical system. Bellman optimality principle and the method of Lyapunov functions. Asymptotic stabilization of movement.

practical teaching
-

prerequisite
None

learning resources
Pontryagin L. S., Boltyanskii V. G., Gamkrelidze R. V., Mishchenko E. F., Mathematical Theory of Optimal Processes (in Russian). Nauka, Moscow, 1983.

Vujanović B.D. and Spasić D.T. : Part II: Fundamentals of Optimal Control Theory", Novi Sad University Press, Novi Sad,2009.

lecture hours of active teaching: 35

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
Fempl S., Elementi varijacionog računa, Građevinska knjiga, Beograd, 1965.
Hull DG, Optimal Control Theory for Applications, Springer, New York,2003.

Subchan S, Zbikowski R, Computational Optimal Control, Tools and Practice, WILEY, UK, 2009.
Leitmann G., An Introduction to Optimal Control, McGraw-Hill , New York,1966.
Sage P, White C , Optimum Systems Control. Prentice-Hall, Englewood, 1977.

Optimization Methods of Mechanical Systems

ID: PhD-3624
responsible/holder professor: Mitrović M. Radivoje
teaching professor/s: Rosić B. Božidar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
ECTS credits: 5
final exam: seminar works

goals
The main goal of this course for the student is to give the necessary knowledge of:

• numerical analysis and optimization,

• understanding general principles of design optimization

• formulating the optimization problems and identify critical elements.

learning outcomes
During this course, the student will carry out:

• Overview of design optimization

• Fundamentals of engineering optimization

• Problem formulation

• strategies for optimization

theoretical teaching
1. Introduction to Modeling and Optimum Design Process. Optimum design problem formulation. A general mathematical model for optimization.

2. Graphical Optimization.Identification of feasible region. Use of MATLAB for graphical optimization.

3. Unconstrained Optimum Design Problems. Optimality conditions for functions of several variables.

4. Engineering design examples with MATLAB.

5. Nonlinear Programming. Problem formulation. Equality constrained problem. Inequality constrained optimization. Basic ideas and algorithms for step size determination.

6. Numerical methods - The One-dimensional Problem. Optimum design examples with MATLAB.

7. Numerical Methods for Unconstrained Optimization. Numerical Methods - Nongradient methods.

Powell's method. Numerical Methods-Gradient-Based Methods. Conjugate Gradient (Fletcher-Reeves) Method. Davidon-Fletcher- Powel (DFP) method.

8. Numerical Methods for Constrained optimization Problem definition. Necessary conditions. Method of feasible directions.Gradient projection method. Exterior penalty function method.

9. Introduction to the Formulation of the Multicriterion Optimization Problem. Decision variables. Constraints. Objective functions.Space of Decision Variables and Space of Objective Functions. Pareto Optimum. Min-Max optimum.

10. Decision Making Problem. Weighting Objectives Method. Goal Programming Method. Interactive Multicriterion optimization method.

11.Genetic Algorithm with MATLAB for optimum design examples.

practical teaching
Consists of the auditory and laboratory exercises. Projects are main component of this course.

prerequisite
Knowledge of linear algebra and numerical mathematics. Computer programming in MATLAB. Some knowledge of basic machine elements and mechanics.

learning resources
Computer Usage:

Students extensively use the computer and optimization toolbox using MATLAB program.

Handout and text books.

lecture hours of active teaching: 35

assessment of knowledge (maximum number of points - 100)
feedback during course study: 5
test/colloquium: 0
laboratory exercises: 15
calculation tasks: 10
seminar works: 40
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references
Jasbir S. Arora " Introduction to Optimum Design", Elsevier Academic Press
P. Venkataraman " Applied Optimization with Matlab Programming" John Wiley and sons, inc.
H. Eschenauer, J. Koski, A. Osyczka: "Multicriteria Design Optimization", Springer-Verlag
Randy L. Haupr, Sue Ellen Haupt: "Practical Genetic Algorithms", John Wiley and sons, inc.

Optimization of aerospace structures

ID: PhD-3257
responsible/holder professor: Simonović M. Aleksandar
teaching professor/s: Dinulović R. Mirko, Simonović M. Aleksandar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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

lecture hours of active teaching: 35

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
R. Ganguli, ENGINEERING OPTIMIZATION: A MODERN APPROACH, CRC Press, 2012
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
responsible/holder professor: Petrović V. Milan
teaching professor/s: Petrović V. Milan
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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. Energy economics: Cost of electricity. Net present value. Economic evaluation methods. System Performance Characteristics and Selection: Performance. Construction costs. Fuel cost. Operation and maintenance cost. Availability and forced outage rates. Load distribution. Models for simulation of components and systems. Optimization: Mathematical model construction. Method of optimization for single-variable functions. Method of optimization for multivariable functions. A simplified cost optimization. Life-cycle power plant optimization. Steam turbine plants optimization. Gas turbine plants optimization. Combined cycle optimization.

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

lecture hours of active teaching: 35

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

Petrovic, M: gas turbines and Turbocompressors, scrip, 2004.
Stojanovic, Themal Turbomachinery, Gradjevinska knjiga, Belgrade, 1967.
A.Bejan, G. Tsatsaronis, M. Moran: Thermal Design and Optimization, Wiley, 1996.
K.W.Li, A.P. Proddy: Power Plant System Design, Wiley, 19985
A. Bejan, Advanced Engineering Thermodynamics, 3rd ed., Wiley, 2006.

Organization and methods of scientific research and communication

ID: PhD-3192
responsible/holder professor: Nedeljković S. Miloš
teaching professor/s: Nedeljković S. Miloš
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
lecture hours of active teaching: 35

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

Nedeljković M. Preporuke za pripremu i izlaganje naučno-stručnih radova. časopis «Procesna tehnika», ISSN 0352-678X, вол..10, бр.1, стр.12-14,Београд 1994.

Dale MG. How to write and publish scientific paper. Oxford University Press, 1993.

Oscillations of mechanical systems

ID: PhD-3490
responsible/holder professor: Obradović M. Aleksandar
teaching professor/s: Mitrović S. Zoran, Obradović M. Aleksandar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Stability of equilibrium of the conservative system. Linearization of the differential equations of motion. Vibration of the conservative system. Frequencies. The main mode shapes of vibration. Modal matrix. Vibration of the body on the beam supports. Damped vibration. Forced undamped vibration. Forced vibration. Resonance. Forced damped vibration of the system. Oscillations (free and forced) of elastic bodies with constant and variable cross section. Oscillations (free and forced) of plates and membranes. Properties of nonlinear oscillations. Testing of stationary systems with one degree of freedom. Phase plane, phase portraits and singular points. Lyapunov theorem. Construction of phase trajectories. The concept of auto - oscillation. Degenerative systems and the hypothesis of a jump. The effect of external harmonic force on auto - oscillation of systems with one and two degree of freedom. Stability of boundary trajectories.

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.

lecture hours of active teaching: 35

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

Meirovitch L, FUNDAMENTALS OF VIBRATIONS, Mc Graw Hill, 2001.
Rao S.S., Mechanical vibrations, Addison-Wesley Publishing Company Inc., 1995.
Rao S.S., Vibration of Continuous Systems, WILEY,2007.

Performance Analysis of Manufacturing Systems

ID: PhD-3011
responsible/holder professor: Babić R. Bojan
teaching professor/s: Babić R. Bojan
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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 classrom for distance learning (http://147.91.26.15/moodle/), University of Belgrade, Faculty of Mechanical Engineering, 2011, 18.13

(3) AnyLogic simulation software

lecture hours of active teaching: 35

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

Guy L. Curry, Richard M. Feldman (2011), Manufacturing Systems Modelling and Analysis, Second Edition, Springer Heidelberg Dordrecht London New York
J. Banks, J. S. Carson, B. L. Nelson and D. M. Nicol (2005), DISCRETE EVENT SYSTEM SIMULATION, 4th Ed., Pearson Education International Series.
H. Tempelmeier, H. Kuhn (1993), FLEXIBLE MANUFACTURING SYSTEMS - DECISION SUPPORT FOR DESIGN AND OPERATION, John Willey & Sons.

Planetary gear train

ID: PhD-3626
responsible/holder professor: Mitrović M. Radivoje
teaching professor/s: Rosić B. Božidar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
ECTS credits: 5
final exam: written

goals
The main goal of this course for the student is to give the necessary knowledge of:

• Computer aided machine design,

• understanding general relations between the gear parameters and those of the basic rack,

• formulating the optimization problems for planetary gear train and identify critical elements.

learning outcomes
During this course, the student will carry out:

• Overview of design machine element,

• methodology for calculation the planetary gear trains,

• strategies for machine design.

theoretical teaching
1. Design strategies. Field of application. Design objectives. Design analysis and evaluation.

2. Preliminary design: design synthesis. Computer aided machine design.

3. Gears in mesh, contact ratio, interference and backlash.

4. Internal gears. Tooth profile an internal gear. Meshing geometry of an internal geair pair.

5. Axial and radial assembly, tip interference.

6. Kinematic structure of the planetary gear train.

7. Force analysis - forces produced by central gear in mesh with planet gears.

8. Instantaneous efficiencies during the contact period and overall efficiency for planetary gear train.

9. Tooth stresses and strengths for external and internal gears of planetary gear train.

10. Optimization of planetary gear train.

practical teaching
Consists of the laboratory exercises.

Projects are main component of this course.

prerequisite
Some knowledge of basic machine elements and mechanics. Computer programming in MATLAB.

learning resources
Laboratory for CAD and laboratory for experimental investigation of gear trains.

lecture hours of active teaching: 35

assessment of knowledge (maximum number of points - 100)
feedback during course study: 5
test/colloquium: 0

laboratory exercises: 15
calculation tasks: 10
seminar works: 40
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

Joseph E. Shigley: "Mechanical Engineering Design", Mc Graw Hill
J.R. "The Geometry of Involute Gears", Springer-Verlag
H. Eschenauer, J. Koski, A. Osyczka: "Multicriteria Design Optimization", Springer-Verlag

Planning, Performing & Controlling Projects

ID: PhD-3334
responsible/holder professor: Babić R. Bojan
teaching professor/s: Babić R. Bojan
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Project initiation phase – Creation of initiation report . Making of conception report, Feasibility report forming, Study phase – specifications. Design phase – work on design tasks. Fall term progress report, preliminary design report. Detailed design report. Project presentation.

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 classrom for distance learning (http://147.91.26.15/moodle/), University of Belgrade, Faculty of Mechanical Engineering, 2011,

lecture hours of active teaching: 35

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
responsible/holder professor: Lučanin J. Vojkan
teaching professor/s: Lučanin J. Vojkan, Tanasković D. Jovan
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Working characteristics of hydrodynamic transmission. Coupling of the internal combustion engine and hydrodynamic inverter. Hydrodynamic coupling. Calculation of hydrodynamic inverter, one-dimensional method - analysis of losses, determine the flow field. Inverter in braking mode. Testing and maintenance of transmissions. Regulated asynchronous drive. Frequency and voltage regulation. Automatic process control. Control of the drive in real time.

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).

lecture hours of active teaching: 35

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
B. Davidovic, V. Lucanin, Hydrodynamic transmission of railway vehicles, Faculty of Mechanical Engineering, University of Belgrade, Belgrade, 2001.
Lj. Krsmanovic, A. Gajic, Turbomachines, Faculty of Mechanical Engineering, University of Belgrade, Belgrade, 2006.

Power transmission units reliability and dynamics

ID: PhD-3627
responsible/holder professor: Mitrović M. Radivoje
teaching professor/s: Ognjanović B. Milosav
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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 design parameters of the gear components based on desired level of reliability, vibration and noise as design consraints. Mastering the methodology of innovative development of gear transmission units.

learning outcomes
PhD student introduced to the research process of reliability, vibration and noise of gear transmission units. Trained for innovative development of gear transmission units.

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. Innovative development of gear units for different areas of application and service conditions. Specific operation and boundary conditions of transmission units with extremely high rotational speeds.

practical teaching
Research, examination of relevant references, experimental determination the probability of service and critical conditions of gear unit components and elementary reliability. Vibration and noise testing of gear transmission units. Numerical analysis of dynamic parameters of gear unit components. Determination of design parameters. Preparation and defense of the seminar work.

prerequisite
No conditions

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.

lecture hours of active teaching: 35

assessment of knowledge (maximum number of points - 100)

feedback during course study: 5
test/colloquium: 0
laboratory exercises: 10
calculation tasks: 0
seminar works: 55

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

references

Ognjanović M.: The noise generation in mechanical systems (in Serbian),- Faculty of Mechanical Engineering 1995.
Ognjanović M.: Reliability and safe service of structures , - Chapter in Monography "From fracture mechanics to structural integrity assessment", (333-352), Belgrade 2004.
Ognjanovic M.: Research of Power Transmission for Efficient Design, - Monography chapter “Konstruktionsmethodik fur Fahrzeugkonzepte” Braunschweig , Bericht Nr. 74, 2010, pp 139-157
Ognjanović M.: Innovative design of technical systems, - Faculty of mechanical engineering - University of Belgrade, 2014
Ognjanović M.: Machine elements, - Faculty of mechanical engineering - University of Belgrade, 2020.

Product Development in Mechanical Engineering

ID: PhD-3517
responsible/holder professor: Miloš V. Marko
teaching professor/s: Ognjanović B. Milosav
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Student doktorskih studija uveden u istrživanje metoda i procesa razvoja novih proizvoda tj. novih tehničkih sistema za budućnost. Uveden novu oblast propulzivnog istraživanja i razvoja metodologije za podsticanje kreativnosti u razvoju novih tehničkih sistema.

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.

lecture hours of active teaching: 35

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
responsible/holder professor: Puzović M. Radovan
teaching professor/s: Mladenović M. Goran, Puzović M. Radovan
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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,...)

lecture hours of active teaching: 35

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-3605
responsible/holder professor: Elek M. Predrag
teaching professor/s: Elek M. Predrag, Micković M. Dejan
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
1. Jaramaz, S., Mickovic, D.: Interior ballistics, Faculty of Mechanical Engineering, Belgrade, 2011. (in Serbian)

2. Steifel, G.: Gun propulsion technology, Progress in astronautics and aeronautics, Vol. 109, New York, 1988.

3. Sutton, G.P., Biblarz, O.: Rocket propulsion elements, Wiley, 2010.

4. Davenas, A.: Solid rocket propulsion technology, Pergamon, 1992.

lecture hours of active teaching: 35

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

Krier, H.: Interior ballistics of guns, Progress in astronautics and aeronautics, Vol. 66, New York, 1979.
Hill, P., Peterson, C.: Mechanics and thermodynamics of propulsion, Pearson, 2010.

Quality Engineering Techniques

ID: PhD-3559
responsible/holder professor: Stojadinović M. Slavenko
teaching professor/s: Stojadinović M. Slavenko
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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 beatwen 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. 4. Facility and technical equipment: Laboratory for production metrology and TQM.

lecture hours of active teaching: 35

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
Stojadinovic, M.S., at al. (2016). Ants colony optimisation of a measuring path of prismatic parts on a CMM. Metrology and Measurement Systems, 23(1), 119-132.

Stojadinovic, M.S., Majstorovic, D.V. (2019), An Intelligent Inspection Planning System for Prismatic Parts on CMMs, Springer International Publishing, 978-3-030-12806-7.
Šibalija, V.T., Majstorović, D.V. (2016). Advanced Multiresponse Process. Optimisation. Springer: Berlin, Germany.
Phadke, M.S. (1995). Quality engineering using robust design. Prentice Hall PTR.
Ross, P.J., & Ross, P.J. (1988). Taguchi techniques for quality engineering: loss function, orthogonal experiments, parameter and tolerance design (No. TS156 R12). New York: McGraw-Hill.

Quantitative Research Methods in Aviation

ID: PhD-3182
responsible/holder professor: Mitrović B. Časlav
teaching professor/s: Bengin Č. Aleksandar, Mitrović B. Časlav
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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 whcih 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

lecture hours of active teaching: 35

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
responsible/holder professor: Bugarić S. Uglješa
teaching professor/s: Bugarić S. Uglješa
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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 multi-disciplinary 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

1. Bugaric, U., Petrovic, D.: Servicing system modelling, Faculty of Mechanical engineering Belgrade, Belgrade, 2011.

2. Bugaric, U.: Methodology for analysis of single position machines work, Foundation Andrejevic, Belgrade, 2003.

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

4. Software: IOR Tutorial (Interactive Operations Research).

5. Personal computers.

lecture hours of active teaching: 35

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.
Cooper, R. B., Introduction To Queueing Theory, Elsevier Nort Holland Inc. 1981.
Hillier, F. S., Lieberman, G. J.: Introduction to operations research (seventh edition), McGraw-Hill, New York, 2000.

Regimes and energy efficiency of thermal power plants

ID: PhD-3435
responsible/holder professor: Petrović V. Milan
teaching professor/s: Petrović V. Milan
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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.

Influence of individual basic parameters and off design operation on the main thermodynamic parameters of the steam turbine units. The cold end of the steam turbine at off design operation. Regulation of the steam turbines. Optimization of part load operation of steam turbine plants. Off design operation of gas turbines. Cooling of the gas turbine at part loads. Off design operation of turbocompressors. Surge limit. Rotating stall. Regulation of the gas turbine. Selection and optimization of the regime of the gas block. Off design operation of combined gas and steam turbines plants.

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

lecture hours of active teaching: 35

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.
Traupel,W.: Thermische Turbomaschinen, Springer verlag, Berlin, 1982
Leyzerovich, A.: Steam Turbines for Modern Fossil-Fuel Power Plants, CRC Press, 2008
Cohen, H., Rogers,G.F.C., Saravanamuttoo, H.I.H.: Gas turbine theory, Logman, 1997.
Cumpsty, N.: Compressor Aerodynamics, Longman Scientific & Technical, 1989

Rehabilitation Biomechanics

ID: PhD-3125
responsible/holder professor: Lazarević P. Mihailo
teaching professor/s: Lazarević P. Mihailo
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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

[1]M.Lazarević,Design of Assistive Medical Devices,(script in preparation),2011

[2]Written abstracts from the lectures (Handouts)

[3]R.Khandpur,Biomedical Instrumentation:Technology and Applications,McGraw-Hill,2004.

[4]D.Prutchi, M. Norris,Design and Development of Medical Electronic Instrumentation:A Practical Perspective of the Design,Construction, and Test of Medical Devices,Wiley-Interscience, 2004.(KCJ)

[5]P.King,R.Fries,Design of Biomedical Devices and Systems,Marcel Dekker, 2003.(KCJ)

[6] M. Kutz,BIOMEDICAL ENGINEERING AND DESIGN HANDBOOK,McGrawHill,Vol.1,2,2009

[7]Ahmed A. Shabana,Computational Dynamics,John Wiley & Sons, Inc., 605 Third Avenue, New York, NY,2001

lecture hours of active teaching: 35

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
Thompson, S.G. , Neurorehabilitation Devices. McGraw Hill,2006
Bronzino JD. The biomedical engineering handbook. Boca Raton, FL: CRC Press; 2000.
Yoseph Bar-Cohen,Biomimetics, Biologically Inspired Technologies,CRC Press Taylor & Francis Group,2006
J. M. Justiniano, V. Gopalaswamy,Practical Design Control Implementation,CRC Press LLC, Boca Raton, Florida,2002

Research and Development Methodology

ID: PhD-3558
responsible/holder professor: Grbović M. Aleksandar
teaching professor/s: Grbović M. Aleksandar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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

5. DS Process Steps

5.1 Reviewing Literature

5.2 Determining Research Focus

5.3 Developing Research Plan for DS-I

5.4 Undertaking an Empirical Study

5.5 Drawing Overall Conclusions

6. Prescriptive Study: Developing Design Support

6.1 Types of Design Support

6.2 Types of PS

6.3 A Systematic PS Process

6.4 Task Clarification

6.5 Conceptualisation

6.6 Elaboration

6.7 Realisation

6.8 Support Evaluation

7. Writing Up: Publishing Results

7.1 Various Forms of Publication and Their Intent

7.2 Overall Structure of a Thesis

7.3 Approaches to Help Structure a Thesis

7.4 Tips on Writing Specific Sections

7.5 Writing Papers

7.6 General Guidelines

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.

lecture hours of active teaching: 35

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
responsible/holder professor: Spasojević-Brkić K. Vesna
teaching professor/s: Žunjić G. Aleksandar, Misita Ž. Mirjana, Spasojević-Brkić K. Vesna
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
1. Risk management framework. 2. Basic principles and methods of risk management. 3. Methods and standards for risk management. 4. Designing risk management framework. 5. The risk management process. 6. Implementation of risk management. 7. Qualitative risk assessment models. 8. Quantitative risk assessment models. 9. Statistical models for risk assessment. 10. Risk management tools.

practical teaching
Case studies in the areas of theory in form of seminal work with possible paper publication.

prerequisite
Enrolled semester.

learning resources
1. Terje Aven and Jan Erik Vinnem, 2007., Risk Management With Applications from the Offshore Petroleum Industry, Springer Series in Reliability Engineering series ISSN 1614-7839, London

2. ESPRIT Course material - "Enhancing Industrial Safety, Environmental Protection and Risk Management in Serbia by means of dedicated Training, Education and Technology Transfer",2009.

3. Greg N. Gregoriou, Advances in Risk Management, PALGRAVE MACMILLAN, ISBN-13: 978–0–230–01916–4, 2009

4. Scientific papers from Scopus, Science Direct and other databases.

lecture hours of active teaching: 35

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

Terje Aven and Jan Erik Vinnem, 2007., Risk Management With Applications from the Offshore Petroleum Industry, Springer Series in Reliability Engineering series ISSN 1614-7839, London
ESPRIT Course material - "Enhancing Industrial Safety, Environmental Protection and Risk Management in Serbia by means of dedicated Training, Education and Technology Transfer",2009.
Greg N. Gregoriou, Advances in Risk Management, PALGRAVE MACMILLAN, ISBN-13: 978–0–230–01916–4, 2009
Scientific papers from Scopus, Science Direct and other databases.

Selected chapters of biomechanics of tissue and organs

ID: PhD-3478
responsible/holder professor: Lazarević P. Mihailo
teaching professor/s: Lazarević P. Mihailo
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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.

Injury of the organ / tissue - the biomechanical modeling them. Biomechanical engineering to prevent tissue trauma. Biomechanical aspects of the growth of tissues / organs. Engineering tissues and organs. History and perspectives of future development of artificial tissue/organ.

practical teaching

Introductory examples of tensor analysis/ 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 / TWV: 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
1.1.YC Fung, Biomechanics: Mechanical Properties of Living Tissues 2nd Ed.Springer- Verlag, 1993.

2.Cowin, S. B.Doty,Tissue Mechanics, Springer Science+Business Media, LLC,2007.

3.Teodor M. Atanackovic et. al.,Theory of Elasticity for Scientists and Engineers,Springer 2000.

4.Francesco Mainardi, Fractional calculus and waves in linear viscoelasticity,Imperial College Press, 2010.

5.M.Lazarević, Lj.Bučanović, Contribution to modelling and dinamical analysis of fractional order system with fundamentals of fractional calculus,Fac.of Mech. Eng. University of Belgrade,2012.

6.Podlubny I. Fractional Differential Equations. Academic Press, San Diego,1999

7.Written abstracts from the lectures (Handouts)

lecture hours of active teaching: 35

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
M,Lai,D.Rubin,E.Crempl, Introduction to Continuum Mechanics,Pergamon Press,1993.
Ed. Joseph D. Bronzino,The Biomedical Engineering HandBook, Second Edition. Boca Raton: CRC Press LLC, 2000
Mezger, Thomas G..The Rheology Handbook, Third Edition, 2011, Vincentz Network, Hanover, Germany
Kilbas, Srivastava, H.M., Trujillo, J.J.Theory and Applications of Fractional Differential Equations. Elsevier, Amsterdam,2006.
Hilfer R, Ed., Applications of Fractional Calculus in Physics,World Scientific, River Edge, NJ, USA, 2000.

Selected chapters of mechanics of robots

ID: PhD-3119
responsible/holder professor: Lazarević P. Mihailo
teaching professor/s: Lazarević P. Mihailo
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Basic concepts of robotic system (RS). Orthogonal transformation of coordinates.Rodriguez formula and the transformation matrix (MT,complex MT of coordinates. Quaternions.Position vectors that define the configuration of the RS, internal and external coordinates of RS. Kinematics of RS:velocity and acceleration of the center of inertia of an arbitrary robot segment(RSE). Angular velocity and angular acceleration of an arbitrary RSE,velocity of gripper tip of RS. Direct and inverse kinematics of robot task. Constraints of RS. Momentum, angular momentum, kinetic energy of arbitrary robot segment of RS. Kinetic energy and the metric tensor of RS. Generalized forces and the principle of ideality RS-different cases. Differential equations (DIFE)of motion of RS. Other methods of forming (DIFE) of motion of RS. DIFE of motion of RS given in the form of kinematic chain with the structure of topological three and in the form of closed-kinematic chain. Additional equations of contraints. Constrained motion of robotic gripper. Equations of motion of RS with Langrange multipliers. Redundant RS. Basic concepts of control RS.

practical teaching
Examples of determining the number of degrees of motion of the RS; Calculation the transformation matrix(MT)- in case of Euler angles, and Hamilton-Rodriguez parameters;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)

3.Wittenburg J., Dynamics of Systems of Rigid Bodies, Teubner, Stuttgart, 1977. (XJ)

4.Craig J., Introduction to Robotics, Mechanics and Control, Addison-Wesley, 1989.

5.Written abstracts from the lectures (Handouts)

6.Cyberbotics Webots - software package

7.NeuroArm-laboratory robot with 7 degrees of freedom.

8.MATLAB,MATHEMATICA-mathematics software packages

9.Kuipers, J.B.: Quaternions and Rotation Sequences: A Primer with Applications to Orbits,Aerospace and Virtual Reality, PrincetonUniversity Press, New Jersey, 1999.

lecture hours of active teaching: 35

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
Bruno Siciliano, Oussama Khatib, Springer Handbook of Robotics,Springer-Verlag Berlin Heidelberg 2008.
Thomas R. Kurfess.,Robotics and automation handbook,CRC Press LLC, Boca Raton, Florida,2005
Ahmed A. Shabana, Dynamics of Multibody Systems,Cambridge University Press The Edinburgh Building, Cambridge , UK,2005.
M.W. Spong, M. Vidyasagar: Robot Dynamics and Control (Wiley, New York 1989)
R. Paul: Robot Manipulators: Mathematics, Programming and Control (MIT Press, Cambridge 1982)

Selected topics from propulsion

ID: PhD-3578
responsible/holder professor: Mitrović B. Časlav
teaching professor/s: Ivanov D. Toni, Mitrović B. Časlav
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
ECTS credits: 5
final exam: written

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
lecture hours of active teaching: 35

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
Ronald D. Flack, «Fundamentals of Jet Propulsion with Applications», Cambrdge University Press 2005
Jack D. Mattigly, »Aircraft Engine Design«, AIAA edu. series, N. Y. 1987.
J. H. Horlock, «Axial flow turbines», Rebert E. Krieger publishing CO., Florida 1985.
S. L. Dixon, «Fluid Mechanics, Thermodynamics of Turbomachinery», Pergamon Press 1981
W. H. Heiser, D. T. Pratt, «Hypersonic Airbreahing Propulsion», AIAA edu. series, Washington, DC. 1994.

Selected Topics in Aerodynamics

ID: PhD-3454
responsible/holder professor: Bengin Č. Aleksandar
teaching professor/s: Bengin Č. Aleksandar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
ECTS credits: 5
final exam: written

goals
Introducing students to selected topics of theoretical and experimental aerodynamic in hyposonic, subsonic, transonic, supersonic and hipersonic 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
Books: Rašuo, B., Two-dimensional Transonic Wind Tunnel Wall Interference, Monographical Booklets in Applied & Computer Mathematics, MB-28/PAMM, Technical University of Budapest, Budapest, 2003, Griebel M., Dornsheifer T., and Neunhoeffer T., Numerical Simulation in Fluid Dynamics, Society for Industrial and Applied Mathematics, 1997, S.B.Pope, Turbulent Flows, Cambridge Univ Pr, 2000, Alexander J. Smits, Jean-Paul Dussauge, Turbulent Shear Layers in Supersonic Flow, 2nd Edition, Springer Verlag, 2005,Herrmann Schlichting, Klaus Gersten, Boundary-Layer Theory, Springer Verlag, 1999, 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.

lecture hours of active teaching: 35

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
responsible/holder professor: Dinulović R. Mirko
teaching professor/s: Dinulović R. Mirko, Simonović M. Aleksandar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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 aeoelasticity 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

lecture hours of active teaching: 35

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

An introduction to the theory of Aeroelasticity, Y.C. Fung, Dover press, 2nd edition
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
responsible/holder professor: Dinulović R. Mirko
teaching professor/s: Dinulović R. Mirko, Simonović M. Aleksandar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
ECTS credits: 5
final exam: project design

goals
Mastering advanced structural analysis methods applied to flying vehicles composite sturctures.

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

lecture hours of active teaching: 35

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

Structural Composites: Advanced Composites in Aviation by Ronald Sterkenburg and Peng Hao Wang (2013)
Experimental Characterization of Advanced Composite Materials, Fourth Edition by Leif A. Carlsson
Advanced Mechanics of Composite Materials and Structural Elements, Third Edition by V.V. Vasiliev

Selected Topics in Bionics

ID: PhD-3444
responsible/holder professor: Bengin Č. Aleksandar
teaching professor/s: Bengin Č. Aleksandar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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

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

practical teaching

Influences Leonardo da Vinci, Sir George Cayley, Otto Lilienthal, Gustave Eiffel, Raoul Francé and Graf von Zeppelin. Bio-strategy application process in fulfilling the spirit of laws rules of biological evolution, which should translate into an acceptable technical solution. Ten basic principles of natural structures. Implementation bionic humanoid proportions and impact on the ergonomic design. Some typical relations (numbers) that characterize the specific effects of similarity and scaling in nature. Bionic Design - views and role models. Wood, vegetable fiber,

animal,: wool, silk, spider web, etc.. Natural resins. Artificial resins - matrix (binder) materials: Epoxy, Polyester, Vinyl ester, phenolic, polyimide, Bizmaleimid et al. Cellular materials, intelligent optical fiber. Electrical and magnetic reostatic. Semiconductor 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.

lecture hours of active teaching: 35

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 Design and Construction - A

ID: PhD-3625
responsible/holder professor: Mitrović M. Radivoje
teaching professor/s: Ristivojević R. Mileta
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
ECTS credits: 5
final exam: written

goals
Acquisition of advanced knowledge ин elaborating alternative construction solutions and optimum choice from the techno-economic and environmental-energy aspects. Essential technical indicators are service life in the area of low-cycle and hi-cycle fatigue and reliability.

learning outcomes
Students will be able to: use the scientific literature on selected areas from

the scope of the Course; independently solve a scientific-research problems from selected area (making of appropriate analytical, numerical and experimental models); individually or as a team member, to write scientific research papers; to transfer knowledge and skills to others.

theoretical teaching
Stages in the process of designing and constructing. Definition of executors

for basic, partial and general functions. The formation of variant solutions and their evaluation - techno economic criteria. Selection of a compromise solution. The variant constructions. The product life cycle. Unification and typization. Measuring chains. The rules and regulations in the design process and constructing. Introduction to basic concepts and regulations related to construction processes in mechanical engineering. The necessity of compliance with regulations. Conformity

Assessment. Harmonized standards. CE marking of products. Placing products on the market. Pressure vessels. Thick and thin walls pressure vessels. Operational stresses. Thermal strain. Critical stresses in static conditions. Selection of welded joints in terms of mutual position of parts to be joined. Types of edges and butt welds (shapes and dimensions) and their application domain. The behavior of structures in the area of low cycle fatigue. The behavior of structures in the

area of high cycle fatigue. Design and construction of welded

structures. Lightweight constructions. Cost effective design in the process

of constructing.

practical teaching
Variant construction solutions. Construction of typizated parts. Executors of elementary and partial functions. Forming and calculation of measuring chains. Application of rules and regulations in the machinery design process. Essay. Calculation problem training in the field of Pressure vessels. Example of constructing in the area of low fatigue load. Dimension calculation of elementary functions executors. Determination of service life. Calculation of light structures. The essay about dimension calculation of elementary and partial functions executors.

Designing from fabrication and assembly point of view.

prerequisite
-

learning resources

Laboratory of Machine design, University of Balgrade, Faculty of Mechanical Engineering. Handouts, Presentations, Wireless Internet connection and access to the course Web presentation provided with usefull links.

lecture hours of active teaching: 35

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 20
laboratory exercises: 20
calculation tasks: 5
seminar works: 25
project design: 0
final exam: 30
requirements to take the exam (number of points): 30

references

Ognjanović M.: Machine design, Faculty of Mechanical Engineering, Belgrade, 2016.
Karl-Heinz Decker: Machinenelemente: Funktion, Gestaltung und Berechnung, Hanser Verlag, 2000
Orlov P.: Fundamentals of Machine Design, MIR Publishers - Moscow, 1980.
S.Veriga: Machine elements 1, Faculty of Mechanical Engineering, Belgrade
Fundamentals of design - a collection of solved calculated problems, MFB, 1999, ZZD, bibl. FME, in sebian

Selected Topics in Design and Construction - B

ID: PhD-3174
responsible/holder professor: Mitrović M. Radivoje
teaching professor/s: Mitrović M. Radivoje
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
ECTS credits: 5
final exam: project design

goals
Acquisition of advanced knowledge ин elaborating alternative construction solutions and optimum choice from the techno-economic and environmental-energy aspects. Essential technical indicators are service life in the area of low-cycle and hi-cycle fatigue and reliability.

learning outcomes
Students will be able to: use the scientific literature on selected areas from the scope of the Course; independently solve a scientific-research problems from selected area (making of appropriate analytical, numerical and experimental models); individually or as a team member, to write scientific research papers; to transfer knowledge and skills to others.

theoretical teaching
Stages in the process of designing and constructing. Definition of executors for basic, partial and general functions. The formation of variant solutions and their evaluation - techno economic criteria. Selection of a compromise solution. The variant constructions. The product life cycle. Unification and typization. Measuring chains. The rules and regulations in the design process and constructing. Introduction to basic concepts and regulations related to construction processes in mechanical engineering. The necessity of compliance with regulations. Conformity Assessment. Harmonized standards. CE marking of products. Placing products on the market. Pressure vessels. Thick and thin walls pressure vessels. Operational stresses. Thermal strain. Critical stresses in static conditions. Selection of welded joints in terms of mutual position of parts to be joined. Types of edges and butt welds (shapes and dimensions) and their application domain. The behavior of structures in the area of low cycle fatigue. The behavior of structures in the area of high cycle fatigue. Design and construction of welded structures. Lightweight constructions. Technologibility in the process of constructing.

practical teaching
Variant construction solutions. Construction of typizated parts. Executors of elementary and partial functions. Forming and calculation of measuring chains. Application of rules and regulations in the machinery design process. Essay. Calculation problem training in the field of Pressure vessels. Example of constructing in the area of low fatigue load. Dimension calculation of elementary functions executors. Determination of service life. Calculation of light structures. The essay about dimension calculation of elementary and partial functions executors. Designing from fabrication and assembly point of view.

prerequisite
-

learning resources
Laboratory of Machine design, University of Balgrade, Faculty of Mechanical Engineering. Handouts, Presentations, Wireless Internet connection and access to the course Web presentation provided with usefull links.

lecture hours of active teaching: 35

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

laboratory exercises: 25
calculation tasks: 15
seminar works: 30
project design: 0
final exam: 30
requirements to take the exam (number of points): 35

references

Ognjanović M.: Machine design, Faculty of Mechanical Engineering, Belgrade, 2000.
Karl-Heinz Decker: Machinenelemente: Funktion, Gestaltung und Berechnung, Hanser Verlag, 2000
Orlov P.: Fundamentals of Machine Design, MIR Publishers - Moscow, 1980.
S.Veriga: Machine elements 1, Faculty of Mechanical Engineering, Belgrade
Fundamentals of design - a collection of solved problems, Faculty of Mechanical Engineering, Belgrade 2017.

Selected Topics in Fluid Mechanics

ID: PhD-3587
responsible/holder professor: Lečić R. Milan
teaching professor/s: Lečić R. Milan, Milićev S. Snežana, Stevanović D. Nevena, Ćoćić S. Aleksandar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
ECTS credits: 5
final exam: written

goals
Bearing in mind that fluid mechanics is a basic theoretical science, it is the goal of the course to familiarize students with the basic laws of maintenance: matter, motion and energy and to master some methods of solving flow problems. That is why different mathematical methods are studied in the course based on: analytical approach (if possible, solution development in order, various transformations, similar solutions, etc., with which it is possible to arrive at flow solutions in some practical, relatively simple cases or geometries).

learning outcomes
As a result of studying fluid mechanics courses, PhD students are familiar with the methods of correct application of equations and calculation methods. Due to the complexity of the basic system of equations describing flow, it is necessary for researchers, when solving specific cases of flow, to identify ways of simplifying the initial system of equations and under what assumptions this applies; then to recognize the possible application of some of the existing analytical or approximation methods, and to acquire a general higher level of knowledge so that they can correctly interpret the results obtained from the calculation.

theoretical teaching
Introductory considerations: voltage state in fluid, rheological models. Basic equations: continuity, Navija-Stokes and energy in conservative and non-conservative form. Boundary and initial conditions. Some correct solutions of the NS equation: stationary flow around the sphere (Stokes and Ozen solution), non-stationary flow around the sphere, flow between parallel plates with variable fluid temperature. Stationary laminar flow through non-circular tubes and ducts. Methods for solving the basic system of differential equations. The concept of linearization of equations. Method of solution development in order.Метода уопштене сличности: примери нестационарног ламинарног струјања преко равне плоче и нестационарно струјање раванског вртлога. Теорија хидродинамичког подмазивања: уопштене Рејнолдсове једначине за слој подмазивања, примери ламинарног струјања у раваском и осносиметричном лежају. Теорија граничног слоја: Прантлове једначине, интегралне једначине граничног слоја, метода Карман-Полхаузена, гранични слој на равној плочи без (Блазијусово решење) и са градијентом притиска (Бокс-Келерова метода).

Compressible laminar boundary layer, application of Stuartson transformations and Crock transformations. An axisymmetric laminar jet. Turbulent flow: averaging modes, Reynolds equations. Methods of modeling turbulent stresses: algebraic and differential: l-mixing path, k-l model, k-epsilon model, k-omega model, etc. Turbulence scales. Kolmogorov theory and turbulence energy spectrum. Spatio-temporal correlations. Turbulenni boundary layer. Flow in a turbulent plane and axisymmetric jet.

practical teaching
Introduction to relevant literature in fluid mechanics - books and scientific journals. Creation of seminar papers from various current fields of research.

prerequisite

It is imperative that undergraduate students have attended basic FLUID MECHANICS courses

learning resources

In fluid mechanics, for the purpose of acquiring profound skills, there are many good foreign books available in the library of the Faculty of Mechanical Engineering, or available online, so that the course is completely littered with literature. To monitor contemporary achievements, it is necessary to use the leading journals in the library: Fluid Mechanics, Physics of Fluid, and others.

lecture hours of active teaching: 35

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

-

Selected topics in fluid structure interaction

ID: PhD-3256
responsible/holder professor: Simonović M. Aleksandar
teaching professor/s: Simonović M. Aleksandar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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

lecture hours of active teaching: 35

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
Y.Bazilevs, K.Takizawa, T.Tezduyar, COMPUTATIONAL FLUID STRUCTURE INTERACTION-METHODS AND APPLICATIONS, Wiley, 2013
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
H.-J. Bungartz, M. Schafer, FLUID-STRUCTURE INTERACTION II, MODELLING, SIMULATION, OPTIMIZATION, SPRINGER,2010
H.-J. Bungartz, M. Schafer, FLUID-STRUCTURE INTERACTION, MODELLING, SIMULATION, OPTIMIZATION, SPRINGER,2006

Selected Topics in Machine Elements - A

ID: PhD-3175
responsible/holder professor: Mitrović M. Radivoje
teaching professor/s: Mitrović M. Radivoje
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
ECTS credits: 5
final exam: seminar works

goals
Studying the behavior of machine parts and components, in general and standard ones in operational and critical conditions, from the surface and volumetric strength, stiffness, operational life stability and energy efficiency point of view. Determination the load essential for the analysis of the operational capacity of machine elements and components,based on analytical, numerical and experimental methods.

learning outcomes
Students will be able to: use the scientific literature on selected areas from the scope of the Course; independently solve a scientific-research problems from selected area (making of appropriate analytical, numerical and experimental models); individually or as a team member, to write scientific research papers; to transfer knowledge and skills to others.

theoretical teaching
Tolerances and fittings. Behavioral problems of machine elements in static and dynamic operational mode. Axles and shafts. Universal (Cardan) joints. Sliding and rolling bearings. Threaded joints. Power transmitions (frictional, gear, belt, chain) - calculation and simulation. Threaded transmition. Couplings. Springs. Inseparable joints.

practical teaching
Service life and strength testing of Machinery parts and systems in laboratory conditions.

prerequisite
None

learning resources
Laboratory of Machine design, University of Balgrade, Faculty of Mechanical Engineering. Handouts, Presentations, Wireless Internet connection and access to the course Web presentation provided with usefull links.

lecture hours of active teaching: 35

assessment of knowledge (maximum number of points - 100)
feedback during course study: 0
test/colloquium: 0
laboratory exercises: 25
calculation tasks: 15
seminar works: 30
project design: 0
final exam: 30
requirements to take the exam (number of points): 0

references
Ognjanović M.: Machine elements, Faculty of Mechanical Engineering, Belgrade, 2011.
Karl-Heinz Decker: Machinenelemente: Funktion, Gestaltung und Berechnung, Hanser Verlag, 2000

Orlov P.: Fundamentals of Machine Design, MIR Publishers - Moscow, 1980.
S.Veriga: Machine elements 1, Faculty of Mechanical Engineering, Belgrade
Z.Stamenic, PhD thesis (area: Cardan shafts), Faculty of Mechanical Engineering, Belgrade, 2012.

Selected Topics in Machine Elements - B

ID: PhD-3623
responsible/holder professor: Mitrović M. Radivoje
teaching professor/s: Ristivojević R. Mileta
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
ECTS credits: 5
final exam: seminar works

goals
Studying the behavior of machine parts and components, in general and standard

ones in operational and critical conditions, from the surface and volumetric strength, stiffness, operational life stability and energy efficiency point of view. Determination the load essential for the analysis of the operational capacity of machine elements and components,based on analytical, numerical and experimental methods.

learning outcomes
Students will be able to: use the scientific literature on selected areas from

the scope of the Course; independently solve a scientific-research problems from selected area (making of appropriate analytical, numerical and experimental models); individually or as a team member, to write scientific research papers; to transfer knowledge and skills to others.

theoretical teaching
Tolerances and fittings. Behavioral problems of machine elements in static and

dynamic operational mode. Axles and shafts. Universal (Cardan) joints. Sliding and rolling bearings. Threaded joints. Power transmissions (frictional, gear, belt, chain) - calculation and simulation. Threaded transmission. Couplings. Springs. Inseparable joints.

practical teaching
Depending on candidates narrow interests, the laboratory resources for general machine design are available.

prerequisite
-

learning resources
Laboratory

of Machine design, University of Belgrade, Faculty of Mechanical

Engineering. Handouts, Presentations, Wireless Internet connection and

access to the course Web presentation provided with usefulm links.

lecture hours of active teaching: 35

assessment of knowledge (maximum number of points - 100)
- feedback during course study: 0
- test/colloquium: 20
- laboratory exercises: 20
- calculation tasks: 5
- seminar works: 25
- project design: 0
- final exam: 30
- requirements to take the exam (number of points): 0

references

Ognjanović M.: Machine elements, Faculty of Mechanical Engineering, Belgrade, 2011.
Karl-Heinz Decker: Machinenelemente: Funktion, Gestaltung und Berechnung, Hanser Verlag, 2000
Orlov P.: Fundamentals of Machine Design, MIR Publishers - Moscow, 1980.
S.Veriga: Machine elements 1, Faculty of Mechanical Engineering, Belgrade
Z.Stamenic, PhD thesis (area: Cardan shafts), Faculty of Mechanical Engineering, Belgrade, 2012.

Selected topics in Machine elements V

ID: PhD-3131
responsible/holder professor: Lazović Kapor M. Tatjana
teaching professor/s: Lazović-Kapor M. Tatjana, Marinković B. Aleksandar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
ECTS credits: 5
final exam: seminar works

goals
Demonstrate knowledge and understanding in the field of machine elements research, based on the current professional knowledge, general knowledge of research methodology, as well as the specific methods of chosen research field (a specific machine element or group of elements, a general methodology for calculating and checking the operational ability of machine parts). Research in the machine elements field implies an analysis of their operational ability in terms of all relevant influences of geometry, mechanical properties of materials, operational conditions (load, speed, frequency, temperature, lubrication...), friction and wear, maintenance, and reliability. Considered machine parts and elements are obtained by conventional manufacturing and processing technologies, as well as by additive manufacturing technologies.

learning outcomes
At the end of the course, in the field of Machine elements research, student should be able to:

- identify and formulate questions autonomously and creatively, with scholarly precision, critically, to select and apply appropriate methods, to undertake a limited part of the research and other professional activities with predetermined time frames, as well as to critically assess the expected results;

- to present and discuss research results;

- demonstrate the skills needed to participate autonomously in research and development work.

theoretical teaching
Review and recap of knowledge obtained in the field of mechanical elements and review the importance of scientific disciplines that are the basis of the study of machine elements. The operational ability of machine elements and all relevant influences. Geometry (shape and size) of machine elements. Materials of machine elements (mechanical properties). A load of machine elements. The load-carrying capacity of machine elements. Load distribution in different machine elements (phenomena description and distribution parameters). Vibration and noise of machine elements. Types of damage and failure analysis of machine elements Tribology of machine elements (lubrication, friction and wear). Reliability and service life of machine elements. Condition monitoring and maintenance of machine elements. Considered machine parts and elements are obtained by conventional manufacturing and processing technologies and by additive production technologies.

practical teaching
Introduction to the analytical, numerical and experimental methods of machine elements research. Introduction to the various forms of machine elements laboratory testing (review and description of methods, devices and means of measurement and data acquisition). Laboratory exercises in the field of selected topics in machine elements investigation. Consultation in the preparation of the seminar work. Considered machine parts and elements are obtained by conventional manufacturing and processing technologies, as well as by additive production technologies.

prerequisite
No special condition.

learning resources

Suggested literature includes the necessary material for lectures, exercises and laboratory work. Required additional material is given at the web site or as hard copy. Large electronic literature can be available to students in direct contact. Lectures are carried out using a blackboard and/or video. Laboratory exercises are carried out in the Machine elements laboratory.

lecture hours of active teaching: 35

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

Ognjanović M.: Machine elements, Faculty of Mechanical Engineering Belgrade (in Serbian)
Mitrović, R., Ristivojević, M., Rosić, B.: Machine elements 1, Feculty of Mechanical Engineering Belgrade (in Serbian)
Krsmanović, V., Mitrović R.: Sliding and rolling bearings, Faculty of Mechanical Engineering Belgrade (in Serbian)
Ristivojević M., Mitrović R.: Load distribution - Gears and rolling bearings. Lazović, T.: Abrasive wear of rolling bearings. Lazović, T:: Service life of ball bearings (all in Serbian)
Appropriate literature (in both serbian and english), available at lecturer office

Selected topics in material handling, constructions and logistics

ID: PhD-3021
responsible/holder professor: Bošnjak M. Srđan
teaching professor/s: Bošnjak M. Srđan, Gašić M. Vlada, Zrnić Đ. Nenad
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Courses: Structural Analysis of Material Handling Mach., Dyn.and Str. of Min. and Construc. Mach., Dynamics of Material Handling and Conveying Mach.

learning resources
1. Computers, Laboratory 516

2. Software Matlab, Catia

lecture hours of active teaching: 35

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 mechanics

ID: PhD-3170
responsible/holder professor: Mitrović S. Zoran
teaching professor/s: Zorić D. Nemanja, Jeremić M. Olivera, Lazarević P. Mihailo, Mitrović S. Zoran, Mladenović S. Nikola, Obradović M. Aleksandar, Radulović D. Radoslav, Tomović M. Aleksandar, Trišović R. Nataša
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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. Lagrange's equations of the second kind (covariant and contravariant form). Analysis of Lagrange's equations. Hamilton's principle. The canonical equations. The dynamics of a system of rigid bodies. The stability condition of the mechanical system. Fundamentals of linear oscillations of mechanical systems. Control. Permissive control. Optimal control. Optimality.

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.

lecture hours of active teaching: 35

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
Gantmaher F.R., Analytical mechanics, (in Russian), Zavod za izdavanje udžbenika SRS, Belgrade 1963.
Pontrjagin L.S., Mathematical theory of optimal control, (in Russian), Fizmatgiz, Moscow 1961.
Leitmann G., An Introducyion to Optimal Control, McGraw-Hill Book Company, 1966.

Rao S.S.: Mechanical vibrations, Addison-Wesley Publishing Company Inc., 1995.
Bakša A.,Vesković M., Stability of a motion (in Serbian), Faculty of Mathematics, Belgrade, 1996.

Selected topics in missile design and launchers

ID: PhD-3621
responsible/holder professor: Marković D. Miloš
teaching professor/s: Marković D. Miloš
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
ECTS credits: 5
final exam: written

goals
The subject is organized through selected chapters that can be considered separately from the aspect of analysis. This is exactly the goal in order to bring the problems of individual subsystems closer to students at a higher level of study.

learning outcomes
Students acquire special knowledge in the field of missile systems through an interdisciplinary approach.

theoretical teaching
Consideration of tactical requirements for rockets and missiles. Kinematic analysis of missile and target. Determination of rocket and missile flight performance. Elements of rocket and missile construction. Homing head. Control unit system. Warhead with fuze. Energy block. Rocket motor. Thrust vector control system. Aerodynamic concept selection. The stress of rocket and missile construction elements. Modal analysis. Launcher design approach depending on the purpose. Launcher construction elements. Rocket-missile-launcher interaction.

practical teaching
Conceptual approach to the design of a rocket through the realization of a software package. Conceptual approach to missile design through the implementation of a software package. Rocket stress analysis through the realization of a software package. Use of FEM software for the purpose of analyzing the rocket and missile stress during flight and transport. Use of FEM software for process analysis and warhead efficiency. Launcher design. Launcher control subsystems. Launcher in the fire control system.

prerequisite
None.

learning resources
lecture hours of active teaching: 35

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

references
E. Fleeman, Missile design and system engineering. American Institute of Aeronautics and Astronautics, 2012.
Zarchan P.: Tactical and Strategic Missile Guidance, Volume 239, Progress in Astronautics and Aeronautics, 2012.

Krasnov N.F. et al.: Rocket aerodynamics, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, June 1971
Siouris G. M.: Missile Guidance and Control Systems, Springer, 2004.
Архангельский И. И.: ПРОЕКТИРОВАНИЕ ЗЕНИТНЫХ УПРАВЛЯЕМЫХ РАКЕТ, МОСКВА, Издательство МАИ 2001.

Selected Topics in Operations Research

ID: PhD-3023
responsible/holder professor: Bugarić S. Uglješa
teaching professor/s: Bugarić S. Uglješa
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
1. Bugaric, U., Petrovic, D.: Servicing system modelling, Faculty of Mechanical engineering Belgrade, Belgrade, 2011.

2. Bugaric, U.: Methodology for analysis of single position machines work, Foundation Andrejevic, Belgrade, 2003.

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

4. Software: QSopt Version 1.0 (Linear programming problems).

5. Software: IOR Tutorial (Interactive Operations Research).

6. Software: MS – Project (Project management).

7. Personal computers.

lecture hours of active teaching: 35

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

Petrić, J.: Operations Research (book 1 & 2), Savremena administracija, Belgrade, 1990.
Žiljak, V.: Computer simulation, Školska knjiga, Zagreb, 1982.
Clymer, J. R.: Systems analysis using simulation and Markov models, Prentice-Hall International Inc., 1990.
Churchman, C. W., Ackoff, R. L., Arnoff, E. L.: Introduction to Operations research, John Willey & Sons Inc., 1957.
Hillier, F. S., Lieberman, G. J.: Introduction to operations research (seventh edition), McGraw-Hill, New York, 2000.

Selected Topics in Programming Tools

ID: PhD-3373
responsible/holder professor: Ristanović R. Milan
teaching professor/s: Ristanović R. Milan
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
ECTS credits: 5
final exam: written

goals

• Learning basic MATLAB commands.

• Mastery of basic knowledge about the software package MATLAB and its applications in scientific research.

• Mastering advanced techniques of MATLAB.

learning outcomes

• Acquisition of basic knowledge of MATLAB.

• Иdentify and use the methods necessary for scientific research using MATLAB software package.

• MATLAB code optimization.

theoretical teaching

Introduction. Ways to use Matlab. Creating variable names. Management of variables. Accessing scripts and function files. Command window management. Online help. Basic Matlab syntax. Some suggestions on how to use Matlab. Matrices and vectors. Creation of vectors. Creation of matrices. Dot operation. Manipulation with matrices. Mathematical operation with matrices. Strings and annotated output. Entering data. Operation with strings. Input/output data files. Naming functions. Debugging functions. The function file. Inline function. Functions of functions - feval. Matlab functions that use feval: zeros of functions, numerical integration, local minimum of function. Numerical solution of ordinary differential equations. Numerical solutions of nonlinear equations. Examples of several Matlab functions: fitting data with polynomials, interpolation of data, fitting data with spline. 2D plotting commands. Graph annotations and visual Enhancement. Lines in 3D. Surfaces. Working with Simulink. Simulink libraries. Creating models in Simulink. S-functions.

practical teaching

Examples of material exposed to the following classes: writing a program in Matlab programming language, with emphasis on advanced techniques and code optimization. Examples of work in the computer lab, the experimental verification of programs written.

prerequisite

Defined by the Curriculum of modules.

learning resources

• Dragan V. Lazic, Milan R. Ristanovic, Introduction to Matlab, Faculty of Mechanical Engineering, 2nd edition, 2012.

• PCs, Computer laboratory, Faculty of Mechanical Engineering

lecture hours of active teaching: 35

assessment of knowledge (maximum number of points - 100)

feedback during course study: 10
test/colloquium: 50
laboratory exercises: 0

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

references

Magrab, B. Edward, "An Engineer's Guide to Matlab", Prentice Hall, Uper Saddle River, NJ 2000.
"Control Tutorials for Matlab", Carnegie Mellon, The University of Michi- gan, http://www.engin.umich.edu/group/ctm/ .

Selected topics in projectile design

ID: PhD-3544
responsible/holder professor: Elek M. Predrag
teaching professor/s: Elek M. Predrag, Micković M. Dejan
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
1. Jaramaz, S.: Warhead design and terminal ballistics, Faculty of Mechanical Engineering, Belgrade, 2000.

2. Lloyd, R.M.: Conventional Warhead Systems Physics and Engineering Design, Progress in Astronautics and Aeronautics, Volume 79, AIAA, 1998.

lecture hours of active teaching: 35

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
responsible/holder professor: Simonović M. Aleksandar
teaching professor/s: Simonović M. Aleksandar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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 abut 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

lecture hours of active teaching: 35

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)
Hau E., Wind turbines: Fundamentals, Technologies, Application, Economics, Springer 2006.
Selected research articles and conference papers
Additional materials (written performed with the lectures, setting tasks, guidelines for solving the task).

Selected topics of Strength of Constructions

ID: PhD-3510
responsible/holder professor: Milovančević Đ. Milorad
teaching professor/s: Balać M. Igor, Buljak V. Vladimir, Milovančević Đ. Milorad
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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. Stresse and strains in beams.

4. Combined loads.

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.

2. Numerical exercises of stress strain analysis. Examples of determination of local and global values for stress and strain.

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 strenght 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.

lecture hours of active teaching: 35

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

John H. Jackson, Harold G. Wirtz :"Statics and Strength of Materials", McGRAW-HILL book co.
Tuma and Munshi:"Advanced Structural Analysis", McGRAW-HILL book co.
William A. Nash:"Strength of Materials 2/ed", , McGRAW-HILL book co.

Selected Topics of Terminal Ballistics

ID: PhD-3068
responsible/holder professor: Elek M. Predrag
teaching professor/s: Elek M. Predrag, Micković M. Dejan
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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

Recapitulation of impact mechanics and shock wave physics. Characterization of the behavior of materials at high strain rates. Experimental methods of terminal ballistics. Analytical modeling of the dynamics of perforation of metal plates. Analytical models for soil, concrete and ceramics penetration. Eroding penetrators - penetration of long-rod projectiles and shaped charge jet. Numerical modeling of penetration.

2. Blast

The formation of the shock wave as a result of the explosion (blast). Modeling of a blast wave. Propagation and reflection of blast waves. Measurement techniques. Scaling blast parameters. Interaction of blast wave and the structure. Numerical simulation of the blast effect.

practical teaching
1. Penetration mechanics

Characterization of material behavior at high strain rates - examples of constitutive laws. Experimental methods of terminal ballistics - measurement techniques. Analytical modeling of metal plate penetration - analysis of different approaches. Analytical models for soil, concrete and ceramic penetration - the application. Eroding penetrators - application of the Tate-Aleksievski model. Numerical modeling of penetration using Abaqus software package.

2. Blast

The basic model of the blast wave - example. Propagation of blast waves in the air. Reflection of blast waves - the Mach wave. Examples of measurement techniques. Models for determination of blast wave parameters. Interaction of shock wave and structures - examples. Numerical simulation of blast effect using Abaqus software package.

prerequisite
No.

learning resources
1. Zukas, J.A.: High velocity impact dynamics, John Wiley and Sons, 1990.

2. Needham, C.E.: Blast waves, Springer, 2010.

3. Carlucci, D.E., Jacobson, S.S.: Ballistics, CRC Press, 2007.

lecture hours of active teaching: 35

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

Rosenberg, Z., Dekel, E.: Terminal Ballistics, Springer, 2012.
Ben-Dor, G., Dubinsky,A., Eleperin, T.: Applied High-Speed Plate Penetration Dynamics, Springer, 2010.
Smith, P.D., Hetherington, J.G.: Blast and Ballistic Loadnig of Structures, Laxton's, 1994.

Selected topis in structural analysis of flying vehicles

ID: PhD-3054
responsible/holder professor: Dinulović R. Mirko
teaching professor/s: Dinulović R. Mirko, Simonović M. Aleksandar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
ECTS credits: 5
final exam: project design

goals
Mastering advanced structural analysis methods in metallic and composite sturctures 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.

lecture hours of active teaching: 35

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 Armement Systems

ID: PhD-3504
responsible/holder professor: Simonović M. Aleksandar
teaching professor/s: Simonović M. Aleksandar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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 trough 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

lecture hours of active teaching: 35

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
responsible/holder professor: Simonović M. Aleksandar
teaching professor/s: Simonović M. Aleksandar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
ECTS credits: 5
final exam: written

goals
The course is linked to the subject taogut 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 adrress 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.

learning resources
Simlab - computer laboratory

lecture hours of active teaching: 35

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
Ferziger J., Perić M., Computational Methods for Fluid Dynamics, Springer Verlag, 1999.
Selected research articles and conference papers.
Additional materials (lecture hand-writings, problem settings, task solving guidelines)

Ship Dynamics

ID: PhD-3418
responsible/holder professor: Bačkalov A. Igor
teaching professor/s: Bačkalov A. Igor
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Solving of nonlinear differential equations of coupled ship motions in waves. Application of nonlinear dynamics methods on ship stability problems.

prerequisite
Completed M.Sc. course in Naval Architecture.

learning resources
Igor Bačkalov, Nonlinear rolling of ships in wind and waves, PhD thesis, 2010.

Scientific papers, available benchmark data and commercial programming languages.

lecture hours of active teaching: 35

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
A.R.J.M. LLoyd, "Seakeeping: Ship Behaviour in Rough Weather"
E. Lewandowski, "The Dynamics of Marine Craft: Maneuvering and Seakeeping", World Scientific, 2004.
O.M. Faltinsen, "Hydrodynamics of High-Speed Marine Vehicles", Cambridge University Press 2005
O.M. Faltinsen, "Sea Loads on Ships and Offshore Structures, Cambridge University Press, 1990
J.N. Newman, "Marine Hydrodynamics", The MIT Press,1992

Ship Waves

ID: PhD-3419
responsible/holder professor: Bačkalov A. Igor
teaching professor/s: Bačkalov A. Igor
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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 oh 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
Milan Hofman, A contribution to the calculation of resistance of a body moving near a free surface, PhD thesis, 1986.

Scientific papers, available model test data and commercial programming languages.

lecture hours of active teaching: 35

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
J.N. Newman "Marine Hydrodynamics", The MIT Press,1992
J. Wehausen "The Wave Wave Resistance of Ships", Advances in Applied Mechanics, 13, 1973
M. Hofman и D. Radojčić "Resistance and propulsion of high speed craft in shallow water", Faculty of Mechanical Engineering, Belgrade 1996
O.M. Faltinsen, "Hydrodynamics of High-Speed Marine Vheicles", Cambridge University Press 2005

Sliding and rolling bearings

ID: PhD-3173
responsible/holder professor: Mitrović M. Radivoje
teaching professor/s: Mitrović M. Radivoje
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
ECTS credits: 5
final exam: written

goals
The acquisition of advanced knowledge in the field of sliding and rolling bearings.

learning outcomes
Students gain the knowledge and skills: of bearing types and their application; to optimize bearing selection in the function of service conditions as well as its material; to properly select/construct a lubrication mechanisam and lubricant type.

theoretical teaching
Friction in sliding bearings and role of lubricants; Sliding bearing types; Introduction in lubrication hydrodynamics theory; Radial bearings with hydrodynamic lubrication; Bearings with hydrostatic lubrication; Sliding bearing materials; Rolling bearing types; Identification system; Tolerances and clearences; Bearing kinematic; Loads and stresses of bearing parts; Bearing capacity; Bearing selection; Lubricants; Lubrication and sealing; Bearing mounting; Articular bearings.

practical teaching
Bearing testing. Dimesional control; Radial clearance determination; Noise and vibrations; Rezidual magnetism; Hardness testing; Acreditated laboratory for rolling bearing testing (LIMES) presentation.

prerequisite
-

learning resources
Acreditated laboratory for machine elements and systems testing (LIMES). Laboratories of Machine Design Department.

lecture hours of active teaching: 35

assessment of knowledge (maximum number of points - 100)
- feedback during course study: 0
- test/colloquium: 0
- laboratory exercises: 25
- calculation tasks: 15
- seminar works: 0
- project design: 30
- final exam: 30
- requirements to take the exam (number of points): 35

references
Sliding and rolling bearings, V.Krsmanović, R.Mitrović, Zavod za izdavanje udžbenika and Faculty of Mechanical Engineering, Belgrade, 2015.
M.Ristivojević, R.Mitrović: Load Distribution - Gear Pairs and Rolling bearings, Belgrade, 2002.
Presentations
Handouts

Software Tools for Project Management

ID: PhD-3347
responsible/holder professor: Babić R. Bojan
teaching professor/s: Babić R. Bojan
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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)

Setting Up Resources (Setting Up People Resources, Setting Up Equipment Resources, Setting Up Material Resources, Entering Resource Pay Rates, Project Management Focus: Getting Resource Cost Information, Adjusting Working Time for Individual Resources, Documenting Resources)

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
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 classrom for distance learning (http://147.91.26.15/moodle/), University of Belgrade, Faculty of Mechanical Engineering, 2011,

lecture hours of active teaching: 35

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-3592
responsible/holder professor: Vorotović S. Goran
teaching professor/s: Bengin Č. Aleksandar, Vorotović S. Goran, Mitrović B. Časlav
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
ECTS credits: 5
final exam: written

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. Appling 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.

lecture hours of active teaching: 35

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 0
laboratory exercises: 30
calculation tasks: 0
seminar works: 0
project design: 40
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
responsible/holder professor: Mitrović B. Časlav
teaching professor/s: Bengin Č. Aleksandar, Dinulović R. Mirko, Mitrović B. Časlav
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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 meneuverability 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.

• Inverse Problems of Stability. Flight in a turbulent atmosphere.

• 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

lecture hours of active teaching: 35

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

R. F. Stengel, Flight Dynamics, Princeton University Press, 2004.
M. J. Abzug and E. E. Larrabee, Airplane Stability and Control: A History of the Technologies that Made Aviation Possible, Cambridge University Press, 2002.
M. Nenadović, Stability and Maneuverability of Aircraft, I, II and III part, Belgrade (1981/1984)
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
responsible/holder professor: Kostić A. Ivan
teaching professor/s: Kostić A. Ivan, Kostić P. Olivera
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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.

lecture hours of active teaching: 35

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
responsible/holder professor: Svorcan M. Jelena
teaching professor/s: Svorcan M. Jelena, Simonović M. Aleksandar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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.

lecture hours of active teaching: 35

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
Griebel M, Dornseifer T, Neunhoeffer T, Numerical Simulation in Fluid Dynamics - A Practical Introduction, SIAM, Philadelphia, 1998.
Wendt J.F. (Ed.), Computational Fluid Dynamics - An Introduction, Springer-Verlag, Berlin Heidelberg, 2009.
Mathews J.H, Fink K.D, Numerical Methods using MATLAB, Prentice Hall, Upper Saddle River,1999.

Anderson J.D.Jr., Computational Fluid Dynamics - The Basics with Applications, McGraw-Hill, New York, 1995.
Ferziger J.H., Perić M., Computational Methods for Fluid Dynamics, Springer-Verlag, Berlin Heidelberg, 2002.

Specific topics in ship hydrodynamics

ID: PhD-3458
responsible/holder professor: Simić P. Aleksandar
teaching professor/s: Simić P. Aleksandar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
ECTS credits: 5
final exam: seminar works

goals
The aims of the course are to familiarize students with contemporary methods for determination of various ship hydrodynamic performances.

learning outcomes
Advanced knowledge in ship hydrodynamics.

theoretical teaching
Contemporary experimental and theoretical methods for determination of hydrodynamic characteristics of various types of ships.

practical teaching
The focus is on the student's independent research in ship hydrodynamics.

prerequisite
Defined by the curriculum of studies.

learning resources
Internet resources, books, scientific and technical journals.

lecture hours of active teaching: 35

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
V. Lewis, Principles of Naval Architecture, Resistance and Propulsion SNAME
Sv. Harvald, Resistance and Propulsion of Ships
J. Carlton, Marine Propellers and Propulsion
M. Hofman and D. Radojcic, Resistance and propulsion of High Speed Crafts in Shallow Water, MF Belgrade, (in serbian)

Stability of Motion of a System

ID: PhD-3171
responsible/holder professor: Mitrović S. Zoran
teaching professor/s: Mitrović S. Zoran
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Nondisturbed and disturbed motion. Stability of a motion. Differential equations of a disturbed motion. Direct Lyapunov's method. Lyapunov functions. Lyapunov's theorem of a stability. Lyapunov's theorem of a asymptotic stability. Lyapunov's theorem of a instability. Chetayev's theorem. Lyapunov function and first integrals. Stability in relation to a part of variables. Stability in linear approximation. Stability of equilibrium state and stationary motion. Stability of equilibrium state of conservative systems. Influence of gyroscopic and dissipative forces. Stability of equilibrium state and stationary motion of a nonholonomic systems.

practical teaching
/

prerequisite
Defined by the curriculum study of Phd studies program.

learning resources
Bakša A.,Vesković M., Stability of a motion (in Serbian), Faculty of Mathematics, Belgrade, 1996.

lecture hours of active teaching: 35

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
Malkin I., Theory of Stability of a Motion, (in Russian), Nauka, Moscow, 1966.

Statistical process control

ID: PhD-3470
responsible/holder professor: Babić R. Bojan
teaching professor/s: Babić R. Bojan
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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/

lecture hours of active teaching: 35

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

John S. Oakland: Statistical Process Control Paperback , 2007
Fred W. Kear, Statistical Process Control in Manufacturing Practice, CRC Press, 1997.

Steam Turbines - Advanced course

ID: PhD-3389
responsible/holder professor: Petrović V. Milan
teaching professor/s: Petrović V. Milan
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Introduction. Thermodynamic Cycles. Selection and optimization of the cycle parameters. Energy and exergy analysis of the steam turbine cycles. Cascade Theory. Loss and deviation models. Stage Theory and 1D Design.

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
Literature. Lab. Experimental facilities. Computing facility.

lecture hours of active teaching: 35

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

Petrovic, M.: Steam turbines, script, 2004.
Stojanovic, Themal Turbomachinery, Gradjevinska knjiga, Belgrade, 1967.
Traupel,W.: Thermische Turbomaschinen, Springer verlag, Berlin, 1982
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
responsible/holder professor: Trišović R. Nataša
teaching professor/s: Trišović R. Nataša, Cvetković S. Aleksandar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
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

Cvetkovic, A., Radojevic, S.: MATLAB I, Faculty of Mechanical Engineering, Belgrade, 2012.

Gilat, A., MATLAB: An Introduction with Applications, John Wiley & Sons, 2005

lecture hours of active teaching: 35

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

Y.K. Lin Probabilistic Theory of Structural Dynamics, Robert E. Krieger publishing Company, Florida, 1976
J. B. Roberts, P.D. Spanos, Random Vibrations and Statistical Linearization, Dover Publications, New York, 1999.
L.C. Ewans, An Introduction to Stochastic Differential Equations,, American Mathematical Society, 2014
A. Cvetkovic, S. Radojevic, MATLAB I, Faculty of Mechanical Engineering, Belgrade, 2012.

Strapdown Inertial Navigation systems

ID: PhD-3599
responsible/holder professor: Todić N. Ivana
teaching professor/s: Todić N. Ivana
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
ECTS credits: 5
final exam: written

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, Rodriges'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
INS algorithms. Influence of sensor errors on inertial navigation. Calibration algorithms. Algorithms of integrated navigation systems.

prerequisite
none

learning resources
Titterton, D.H. and Weston, J.L., ”Strapdown Inertial Navigation Technology – 2nd edition”, IEE Radar, Sonar, Navigation and Avionic Series 17, ISPB 0-86341-358-7, 2004

Savage, P.G., ”Strapdown Inertial Navigation Integration Algorithm Design Part 1: Attitude Algorithms”, Journal of Guidance, Control, and Dynamics, Vol. 21, No. 1, pp. 19-28, Jan.-Feb. 1998

Savage, P.G., ”Strapdown Inertial Navigation Integration Algorithm Design Part 2: Velocity and Position Algorithms”, Journal of Guidance, Control, and Dynamics, Vol. 21, No. 2, pp. 208-221, Mar.-Apr. 1998

Salychev, O., “Inertial Systems in Navigation and Geophysics”, Bauman MSTU Press, ISBN 5-7038-1346-8, MOSCOW 1998

Salychev, O., “Applied Inertial Navigation: Problems and Solutions”, Bauman MSTU Press, ISBN 5-7038-2395-1, MOSCOW 2004

lecture hours of active teaching: 35

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

Titterton, D.H. and Weston, J.L., ”Strapdown Inertial Navigation Technology – 2nd edition”, IEE Radar, Sonar, Navigation and Avionic Series 17, ISPB 0-86341-358-7, 2004
Salychev, O., “Inertial Systems in Navigation and Geophysics”, Bauman MSTU Press, ISBN 5-7038-1346-8, MOSCOW 1998
Salychev, O., “Applied Inertial Navigation: Problems and Solutions”, Bauman MSTU Press, ISBN 5-7038-2395-1, MOSCOW 2004

Stress and strain measurement

ID: PhD-3161
responsible/holder professor: Milovančević Đ. Milorad
teaching professor/s: Milovančević Đ. Milorad
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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. Handauts from the website of Department.

2.V.Brcic, R.Cukic,Experimental methods in the design of structures, building books, Belgrade (1988)

lecture hours of active teaching: 35

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
responsible/holder professor: Gašić M. Vlada
teaching professor/s: Gašić M. Vlada
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Introduction notes upon the characteristic structural solutions (trusses and beams) material handling machines. Basic equations of the theory of elasticity. Basics in theory of plates. Finite element method (beam/truss, plate/shell, solid). Dynamics of structures. Moving load problem.

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

lecture hours of active teaching: 35

assessment of knowledge (maximum number of points - 100)
feedback during course study: 0
test/colloquium: 0
laboratory exercises: 0
calculation tasks: 0
seminar works: 30
project design: 0
final exam: 70
requirements to take the exam (number of points): 30

references

Petković, Z.: Metalne konstrukcije u Mašinogradnji 2, Beograd, 2005
Clough R.W., Penzien J., Dynamics of structures, New York, McGraw-Hill, 1993
Paz M., Leigh W., Structural dynamics: Theory and Computation, Kluwer, 2004

Structural Integrity and Life

ID: PhD-3221
responsible/holder professor: Radaković J. Zoran
teaching professor/s: Radaković J. Zoran
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Practical exercises: Linear elastic fracture mechanics. Effects of stress concentration on material defects. Griffith equilibrium energy. Energy release rate. R-curve. J integral. Fracture mechanisms in metals. Ductile fracture. Cleavage. Ductile to brittle fracture transition. Intercrystalline fracture. Testing the fracture toughness. K-R curves. Testing the J integral. CTOD. Testing the fracture of welded joints. Laboratory exercises. Consultations.

prerequisite

Math. 1-3, Mechanics 1-3, Eng. materials 1-2, Physics and Meas., Strength of mater., 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.

lecture hours of active teaching: 35

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

T.L. Anderson, Fracture Mechanics - Fundamentals and Applications, CRC Press, 1995.
M.F. Kanninen, C.H. Popelar, Advanced Fracture Mechanics, Oxford University Press, 1985.
A. Saxena, Non-Linear Fracture Mechanics for Engineers, CRC Press, 1998.
G. P. Cherepanov, Mechanics of Brittle Fracture, McGraw-Hill International Book Co., 1979.
A. F. Liu, Structural Life Assessment Methods, ASM International, 1998.

Structure testing methods

ID: PhD-3516
responsible/holder professor: Marinković B. Aleksandar
teaching professor/s: Ognjanović B. Milosav
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Work in laboratory. Testing process preparation and testing realization. Experimental results processing. Seminar work processing. Defense of seminar work.

prerequisite
no specific conditions

learning resources
Laboratory for gears and gear transmission units. Laboratory for vibration and noise of machine systems components.

lecture hours of active teaching: 35

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

John J.A., Quenouille M.H.: EXPERIMENTS: Design and Analzsys, - Griffin – London 1997;
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-3603
responsible/holder professor: Šiniković B. Goran
teaching professor/s: Šiniković B. Goran
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
ECTS credits: 5
final exam: written

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
Principles of analysis of human movement. Techniques for use of this analysis in the integration of mechatronic systems. Existing driving systems. Basics of the synthesis of mechanisms. Sensors. Basics of an PLC. Introduction to the existing solutions, especially in the food industry.

practical teaching
Not provided.

prerequisite
No conditions.

learning resources
-

lecture hours of active teaching: 35

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
responsible/holder professor: Vencl A. Aleksandar
teaching professor/s: Vencl A. Aleksandar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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 running-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

1. A. Rac, Fundamentals of Tribology, Faculty of Mechanical Engineering, Belgrade, 1991, (in Serbian).

2. A. Rac, Lubricants and Machine Lubrications, Faculty of Mechanical Engineering, Belgrade, 2007, (in Serbian).

3. T.R. Thomas, Rough Surfaces, Imperial College Press, London, 1999.

4. F.F. Ling, Surface Mechanics, John Wiley & Sons, New York, 1973.

5. G.E. Totten, H. Liang, Surface Modification and Mechanisms, Marcel Dekker, New York, 2004.

6. K. Holmberg, A. Matthews, Coatings Tribology, Elsevier, Amsterdam, 2009.

7. E. Gnecco, E. Meyer, Fundamentals of Friction and Wear on the Nanoscale, Springer, Berlin, 2007.

8. B. Bhushan (Ed.), Nanotribology and Nanomechanics: An Introduction, Springer, Berlin, 2005.

lecture hours of active teaching: 35

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

N.D. Spencer, Tailoring Surfaces – Modifying Surface Composition and Structure for Applications in Tribology, Biology and Catalysis, World Scientific Publishing, Singapore, 2011.
C.M. Preece (Ed.), Treatise on Materials Science and Technology – Erosion, Vol. 16, Academic Press, New York, 1979.
D. Scott, ed., Treatise on Materials Science and Technology – Wear, Vol. 13, Academic Press, New York, 1979.
C. Mathew Mate, Tribology on the Small Scale, Oxford University Press, New York, 2008.
B. Bhushan (Ed.), Handbook of Micro/Nano Tribology, CRC Press, Boca Raton, 1999.

Synthesis of mechanisms

ID: PhD-3533
responsible/holder professor: Popkonstantinović D. Branislav
teaching professor/s: Popkonstantinović D. Branislav, Stojićević D. Miša
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Development of machine science. The fundamental concept of mechanisms. Kinematic modeling. Typical, numerous and dimensional synthesis. Coupling points and their use in machines. Synthesis in infinitely close positions. Euler-Savari equation. Cuban curves steady curves. Using synthesis in infinitely close positions in engineering practice. Geometric methods of synthesis for two and three exact points. Fundamentals and Burmaster theories of synthesis at four exact points. Algebraic synthesis methods using complex numbers. Nonlinear programming methods and their application in synthesis mechanisms.

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

lecture hours of active teaching: 35

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

Erdman G.A., Sandor N.G., MECHANISM DESIGN - ANALYSIS AND SYNTHESIS, Prentice-Hall, London, 1997, ISBN 0-13-273343-9; Norton L.R., DESIGN OF MACHINERY, McGraw-Hill, New York, 2004, ISBN 0-07-121496-8;

Systems of artificial neural networks

ID: PhD-3168
responsible/holder professor: Miljković Đ. Zoran
teaching professor/s: Miljković Đ. Zoran
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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/

[2] Z. Miljković, Systems of artificial neural networks in production technologies, Series IMS, Vol. 8, University of Belgrade, Faculty of Mechanical Engineering, 2003, 18.1 /In Serbian/

[3] 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

lecture hours of active teaching: 35

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

Z.Miljković, D.Aleksendrić, (2018, 2nd ed.) ARTIFICIAL NEURAL NETWORKS–SOLVED EXAMPLES WITH THEORETICAL BACKGROUND (in Serbian). University of Belgrade–Faculty of Mechanical Engineering, Belgrade.
Freeman, J.A., Skapura, D.M., (1991) NEURAL NETWORKS – ALGORITHMS, APPLICATIONS AND PROGRAMMING TECHNIQUES, Addison-Wesley Publishing Company.
Golden, R.M., (1996) MATHEMATICAL METHODS FOR NEURAL NETWORK ANALYSIS AND DESIGN, MIT Press.
Skapura, D.M., (1996) BUILDING NEURAL NETWORKS, Addison-Wesley Publishing Company.
Zalzala, A.M.S., Morris, A.S., (1996) NEURAL NETWORKS FOR ROBOTIC CONTROL -THEORY AND APPLICATIONS, Ellis Horwood Limited.

Technical Legislation - Directives and Standards

ID: PhD-3177
responsible/holder professor: Mitrović M. Radivoje
teaching professor/s: Mitrović M. Radivoje
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
ECTS credits: 5
final exam: seminar works

goals
Acquiring of advanced knowledge in the field of technical regulations and standards. Fully understanding the mutual correlation between international and national technical regulations. Full training for the project documentation making in terms of respect for the essential requirements relevant to technical regulations and standards.

learning outcomes
Students gain advanced knowledge about the content, significance and types of technical regulations and standards, technical legislation of EU directives, conformity assessment procedures, notified bodies, CE marking, market surveillance, machinery safety, risk assessment and national legislation on safety and health at work. The acquisition of appropriate competencies, skills and know-how to use the appropriate technical regulations and standards.

theoretical teaching
The role, importance and types of technical regulations in mechanical engineering. The place and role in the process of technical regulations and machinery design. Standardization. Application scope. Lows about standardization. Low of Accreditation. Low of Metrology. Lows of Technical Directives. Directives and other regulatory legislation documents. EU technical legislation. EU directives. The meaning of new and global approach. Scope of application of the New Approach Directives. Products and goods covered by directives. Compatibility to the Directives. Standard procedure for conformity assessment. Modules. Quality standards application. Notified bodies. Principles of Accreditation. The process of certification. Notified bodies and subcontracting. Coordination and cooperation of notified bodies. CE marking. The principles of the CE markings. Products which is marked with CE. Market surveillance. Principles of market surveillance. Machinery safety. Reliability. Hazard. Risk. Functions of machinery safety. Safety protection. Manual Instruction. Strategy for selection of safety measures. Risk assessment. The evaluation of risk. Law on Safety and Health at work.

practical teaching
Examples of application and use of various types of technical regulations and standards in the construction and design process. Examples of formation and complete technical documentation for obtaining the CE mark for the product. Examples of forming and completing the documentation for the accreditation of laboratories for product testing. Examples and conformity assessment of products. Examples of designing technical solutions for machinery safety and protection. Example of making manual instructions for machinery, equipment or installations. Examples of risk assessment for machinery and mechanical systems. Examples of completing a documentation for the risk assessment. During course, students will visit the following institutions:

- Certified Laboratory for Machinery Elements and System Testing - LIMES, University of Belgrade, Faculty of Mechanical Engineering;
- The Intellectual Property Office of Republic of Serbia;
- Institute for Standardization of Serbia;
- Notified Body of Vinča Institute.

prerequisite
There are no special requirements for attending the course.

learning resources
- Teaching material: Instructions for the application of directives based on new approach and global approach - Danish Technological Institute (translated version) 2006, EU Directive, EU Standards, Standards of Republic of Serbia, the Law on Standardization, the Law on Accreditation Act, the Law on Metrology, Lawc on technical regulations. Required additional materials (handouts, Directives Of Republic of Serbia, etc..) are given at the web site or as a hard copy. Large-scale electronic materials can be made available to students in direct contact.

- Computer equipped classroom;

- Access to Internet;

- Laboratory for General Machine Design, University of Belgrade, Faculty of Mechanical Engineering;

- Certified Laboratory for Machinery Elements and System Testing - LIMES, University of Belgrade, Faculty of Mechanical Engineering;

- Certified Laboratory for Vehicle Testing - CIAH, University of Belgrade, Faculty of Mechanical Engineering;

lecture hours of active teaching: 35

assessment of knowledge (maximum number of points - 100)

feedback during course study: 0
test/colloquium: 20
laboratory exercises: 0
calculation tasks: 0
seminar works: 40
project design: 0
final exam: 40
requirements to take the exam (number of points): 35

references
Fundaments of Technical Regulatives, Faculty of Mechanical Engineering, Belgrade, 2015.
Actual Directives and regulation books of Reublic of Serbia
EU Directives (MD, LVD, EMC, HACCP, ATEX,...)
Technical regulations and standards, textbook in preparation

Tensor Calculus

ID: PhD-3550
responsible/holder professor: Zorić D. Nemanja
teaching professor/s: Zorić D. Nemanja
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Basic basis. Conjugated basis. Components of metric tensor. Dyadic product. Bivalent tensors. Tensors of higher valence. Metric tensor. Simple operations over tensors. Symmetric and anti-symmetric bivalent tensors. Scalar product of tensors. Double scalar product of tensors. Pseudo-tensors. Vector product of tensors. Own vectors and own values. Tensor differentiation. Bivalent tensor derivation. Metric tensor differentiation. Tensor divergences. Orthogonal curvilinear coordinates. Lamé's coefficients. Christophel's symbols. Tensor rotor. Laplacian. The application to analytical mechanics and continuum mechanics.

practical teaching
Basic basis. Conjugated basis. Components of metric tensor. Dyadic product. Bivalent tensors. Tensors of higher valence. Metric tensor. Simple operations over tensors. Symmetric and anti-symmetric bivalent tensors. Scalar product of tensors. Double scalar product of tensors. Pseudo-tensors. Vector product of tensors. Own vectors and own values. Tensor differentiation. Bivalent tensor derivation. Metric tensor differentiation. Tensor divergences. Orthogonal curvilinear coordinates. Lamé's coefficients. Christophel's symbols. Tensor rotor. Laplacian. The application to analytical mechanics and continuum mechanics.

prerequisite
Defined by the curriculum study of Phd studies program.

learning resources
[1] Andjelić T.: Tenzorski račun, Naučna knjiga, Beograd, 1980.

[2] Leko M., Plavšić M.: Rešeni problemi iz tenzorskog računa sa primenama u mehanici, Gradjevinska knjiga, Beograd, 1973.

lecture hours of active teaching: 35

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

Andjelić T.: Tenzorski račun, Naučna knjiga, Beograd, 1980.
Leko M., Plavšić M.: Rešeni problemi iz tenzorskog računa sa primenama u mehanici, Gradjevinska knjiga, Beograd, 1973.

Testing and optimization of machine tools

ID: PhD-3428
responsible/holder professor: Živanović T. Saša
teaching professor/s: Živanović T. Saša
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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.

lecture hours of active teaching: 35

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
R. V. Rao, V.J. Savsani, Mechanical Design Optimization Using Advanced Optimization Techniques, Springer, 2012, ISBN 978-1-4471-2747-5.
P. W. Christensen, A. Klarbring, An Introduction to Structural Optimization, Springer, 2009, ISBN 978-1-4020-8665-6.
Z. Zhou, S. (Shengquan) Xie, D. Chen, Fundamentals of Digital Manufacturing Science, Springer, 2012, ISBN 978-0-85729-563-7.
W. Ahmed, K. A. Raouf, K. Cheng, Virtual Manufacturing, Springer, 2011, ISBN 978-0-85729-185-1.
X. Xu, Integrating Advanced Computer-Aided Design, Manufacturing, and Numerical Control: Principles and Implementations, Information Science reference, 2009, ISBN 978-1-59904-714-0.

The dynamics of a viscous incompressible fluid

ID: PhD-3500
responsible/holder professor: Lečić R. Milan
teaching professor/s: Lečić R. Milan, Ćoćić S. Aleksandar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Vector and tensor algebra. Tensors in fluid mechanics. Differential operators. Integral theorems. Continuum hypothesis – continuum mechanics. Conservation laws of mass, momentum and energy. Invariant forms of conservation equations. Reology and constitutive relations. Newtonian fluid. Analysis of Navier-Stokes equations. Laminar, steady and unsteady unidirectional flows. Dimensionless forms of conservation equation. Dimensionless numbers. Approximative methods - perturbation methods. Lubrication theory. Reynolds equation for lubrication. Laminar flow over a sphere.
practical teaching
Algebraic and differential operations with vectors and tensors. Principal values and directions of tensors. Tensor invariants. Invariant form of Navier-Stokes equations. Navier-Stokes equations in cartezian, polar and spherical coordinates. Steady and unsteady Coutte flow. Steady and unsteady Pouiselle flow. Steady laminar flow between rotating cylinders. Superposition of Coutte and Pousille flow. Flow near a plate suddenly set in motion. Flow due to an oscillating plate. Laminar flow in channel of rectangular and triangular cross-section. Laminar flow in a pipe of elliptical cross-section.

prerequisite
-

learning resources
-

lecture hours of active teaching: 35

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: VISCOUS FLUID FLOW, CRC Press LLC 2000
Frank M. White: VISCOUS FLUID FLOW, McGraw Hill, Inc.
R. L. Panton, Incompressible Flow, 4rd Edition, Wiley, 2013.

The integration of aeronautical systems and avionics

ID: PhD-3502
responsible/holder professor: Petrović B. Nebojša
teaching professor/s: Petrović B. Nebojša
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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

lecture hours of active teaching: 35

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-3615
responsible/holder professor: Popović D. Mihajlo
teaching professor/s: Popović D. Mihajlo
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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.

lecture hours of active teaching: 35

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
Schey A. John , Introduction Manufacturing Processes, University of Waterloo, Ontario, 2000.

Konig W., Fertingungsverfahren Band 1 – Drehen, Frasen, Bohren, VDI Verlag,1990.
Tanović Lj., Petrakov Y.V., Theory and Simulation of the Machining Process, FME, Belgrade, 2007
Groover P.Mikell, Fundamentals of Modern Manufacturing, Jonh Wiley & Sons, 2002

Theory of elasticity

ID: PhD-3541
responsible/holder professor: Milošević-Mitić O. Vesna
teaching professor/s: Anđelić M. Nina, Milošević-Mitić O. Vesna
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Cauchy's principle. Stress components in Cartesian and cylindrical coordinate system. Stress tensor. Equilibrium equation in Cartesian and cylindrical coordinate system. Transformation of stress tensor. Principal stresses. Stress invariants. Volume and deviator components. The maximum shear stress. Plane state of stress. Deformation, Lagrange's strain. Small deformation. Geometric interpretation. Compatibility equations. The main deformations. Volume and deviator components. Hypotheses about the collapse of material. Plane state of strain. The rate of strain. Linear elasticity. Hooke's law. Lame 'constants. Thin plates.

practical teaching
Determination of the stress components on the base of balance equations. Determination of the stress components in oblique plane - transformation of stress tensor. Principal stresses, the intensity, the position. The maximum shear stress, the intensity and position. Stress invariants. Calculation of the main strains. Application of hypothesis. Tensors of stress and strain for an elastic body. Thin simply supported plates.

prerequisite
Set by the Curriculum of the study program

learning resources
Handouts from the website of the Department for Strength of the constructions

lecture hours of active teaching: 35

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
responsible/holder professor: Jeremić M. Olivera
teaching professor/s: Jeremić M. Olivera
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Dynamics of a rigid body rotating about a fixed point. Approximate theory of symmetrical, rapidly spinning gyroscope. Gyroscopic moment. Case of regular precession of symmetrical gyroscope. Fast and slow precession. Examples from technical practice. Differential equations of rotation for symmetrical gyroscope. Gyroscopes with three degrees of freedom. Disturbance of stability of the axis of rapidly spinning gyroscope in the case of restraining its degrees of freedom. Pseudo-regular precession under the action of constant moment under the action of gravitational forces. Differential equations of motion for symmetrical gyroscope. Determination of angle of nutation. Case of rapidly spinning gyroscope. Frictional force action on the motion of the axis of gyroscope. Gyroscope in a Cardan's suspension. The gyrocompass. The gyroscopic stabilizers.

practical teaching
Dynamics of a rigid body rotating about a fixed point. Approximate theory of symmetrical, rapidly spinning gyroscope. Gyroscopic moment. Case of regular precession of symmetrical gyroscope. Fast and slow precession. Examples from technical practice. Differential equations of rotation for symmetrical gyroscope. Gyroscopes with three degrees of freedom. Disturbance of stability of the axis of rapidly spinning gyroscope in the case of restraining its degrees of freedom. Pseudo-regular precession under the action of constant moment under the action of gravitational forces. Differential equations of motion for symmetrical gyroscope. Determination of angle of nutation. Case of rapidly spinning gyroscope. Frictional force action on the motion of the axis of gyroscope. Gyroscope in a Cardan's suspension. The gyrocompass. The gyroscopic stabilizers.

prerequisite
Defined by the curriculum study of Phd studies program.

learning resources
Nikolay E.; Theory of Gyroscopes, Gostehizdat, 1948.

Nikolay E.; Gyroscope and its Technical Application, 1947.

Luntz J.; Introduction to Theory of Gyroscopes, Nauka, Moscow, 1972.

lecture hours of active teaching: 35

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

Nikolay E.; Theory of Gyroscopes, Gostehizdat, 1948.
Nikolay E.; Gyroscope and its Technical Application, 1947.
Luntz J.; Introduction to Theory of Gyroscopes, Nauka, Moscow, 1972.

Theory of hydrodynamic stability

ID: PhD-3135
responsible/holder professor: Lečić R. Milan
teaching professor/s: Lečić R. Milan
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
ECTS credits: 5
final exam: oral

goals
Gaining knowlegde 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 researh in this area of fluid dynamics.

theoretical teaching
Fundamental concepts of hydrodynamic stability. Kelvin-Helmholtz instability. Thermal instability. Centrifugal instability, the Taylor problem, the Dean problem and the Gortler problem.The inviscid and viscous theory for parallel shear flow. Heuristic methods of approximation. Approximations to the eigenvalue relation. Symmetrical flows in a channel. Flows of the boundary layer type. Numerical methods of solution. Stabiity characteristics of various basic flows. Plane Coutte flow, Poiseuille flow in a circular pipte, Plane Poiseuille flow. Uniform asymptotic approximations. Additional topics in linear stability theory. Nonlinear stability. Fundamental concepts of nonlinear stability. Additional fundamental concepts of nonlinear stability.

practical teaching
Calculations of linear stability problems in laminar flows.

prerequisite
Passed exam in Selected Chapters in Fluid Mechanics.

learning resources
lecture hours of active teaching: 35

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
P.G. Drazin, W.H.Reid: Hydrodynamic stability, Cambridge University press, 2004.

Thermal comfort and indoor environmental quality in buildings

ID: PhD-3576
responsible/holder professor: Bajc S. Tamara
teaching professor/s: Bajc S. Tamara
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
ECTS credits: 5
final exam: written+oral

goals
Acquiring knowledge and skills in the field of thermal comfort and indoor air quality – standards and legislation in the field of thermal comfort; thermal comfort indicators; methodology of thermal comfort indicators' calculation; evaluation of indoor environmental quality in buildings; indoor environmental quality impact on occupants' health and productivity; standards and methodology of questionnaires and occupants survey for different types of buildings; statistical data processing; measures for improvement of thermal environmental quality; equipment and measurements for thermal comfort and indoor environmental quality evaluation.

learning outcomes
Students acquire specific skills and knowledge in the field of thermal comfort and indoor environmental quality; get familiar with methods for thermal comfort indicators' calculation, which further determine category of thermal environment and can be applied in practice. Student connects advance knowledge and techniques and applies them in practical, experimental research in laboratory and during the measurements in real environments.

theoretical teaching
The concept of thermal comfort and indoor environmental quality; international legislative in the field of thermal comfort; thermal comfort indices and thermal environment categories for different types of buildings; local thermal comfort indices; lighting and noise comfort level; occupants' productivity and health and their correlations with indoor environmental quality; occupants' survey; statistical survey methodology for indoor environmental quality analysis; creation of questionnaires; statistical data processing; measures for improvement of thermal environmental quality.

practical teaching
Practical skills consist of parts: Calculation of thermal comfort indices and building thermal category – handling with measuring equipment, measuring of main physical parameters of thermal comfort: air temperature, surfaces temperature, radiant temperature, air speed, relative humidity, CO2 concentration; determination of personal factors; design of questionnaires for occupants survey and methods for surveying in situ; model creation and validation for building thermal comfort simulation. Individual project task – measurements, statistical and numerical methods on the adequate building example.

prerequisite
Without conditions.

learning resources
Books and scientific literature; standards; measuring equipment.

lecture hours of active teaching: 35

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): 70

references

Bajc T., Indoor environmental quality in buildings - handouts, University of Belgrade Faculty of Mechanical engineering, Belgrade, Serbia, 2019.
***, ASHRAE Handbook, NE Atlanta, GA 30329, 2018.
***, CIBSE Guide A – environmental design, Norfolk NR6 6SA, 2015.
***, CIBSE Concise Handbook, Norwich, Norfolk NR6 6SA, 2008.

Thermal Power Plant Engineering

ID: PhD-3388
responsible/holder professor: Petrović V. Milan
teaching professor/s: Petrović V. Milan
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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

Power Plant Thermodynamic Cycles. Steam Turbine Systems. Condensers. Cooling System Design. Optimization of the steam turbine cold end in power plants. Design and optimization of the feed water heating system. Selection of site for fossil fuel fired power plant. Measurements in power plants. Test of steam turbine and gas turbine power plants. Ecological aspects of power generation. Cogeneration.

practical teaching

Model and software development

prerequisite

PhD student - Thermal power engineering.

learning resources

Literature. Computing facilities

lecture hours of active teaching: 35

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

Petrovic, M: gas turbines and Turbocompressors, scrip, 2004.
Stojanovic, Themal Turbomachinery, Gradjevinska knjiga, Belgrade, 1967.
A.Bejan, G. Tsatsaronis, M. Moran: Thermal Design and Optimization, Wiley, 1996.
K.W.Li, A.P. Proddy: Power Plant System Design, Wiley, 19985
A. Bejan, Advanced Engineering Thermodynamics, 3rd ed., Wiley, 2006.

Thermal-Hydraulics of Steam Generators

ID: PhD-3525
responsible/holder professor: Stevanović D. Vladimir
teaching professor/s: Stevanović D. Vladimir
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Types of steam generators, boiling inside tubes and on the outer surface of tubes in a tube bundle. Two-phase flow patterns and heat transfer mechanisms. Homogeneous, drift flux, two-fluid and multi-fluid models of two-phase flow. Closure laws for the prediction of mass, momentum and energy interface transfer. Boiling crisis. Gas liquid separation at the swell level. Instability of natural and forced circulation. Control volume methods for the solving of two-phase flow models. Safety of steam generators. Condensation induced water-hammer.

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.

lecture hours of active teaching: 35

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

Ishigai, S., Steam Power Engineering - Thermal and Hydraulic Design Principles, Cambridge University Press, 2010.
Reznikov, M.I., Lipov, Yu.M., Steam Boilers of Thermal Power Plants, Mir Publishers, Moscow, 1985.
Delhaye, J.M., Thermohydraulics of Two-Phase Systems for Industrial Design and Nuclear Engineering, Hemisphere, 1981.
Stevanovic, V., Thermal-Hydraulics of Steam Generators – Modelling and Numerical Simulation, University of Belgrade, Faculty of Mechanical Engineering, 2006.
Versteeg, H.K., Malalasekera, W., An introduction to Computational Fluid Dynamics, Longman Group Ltd., Harlow, 1995.

Thermoelasticity

ID: PhD-3163
responsible/holder professor: Milošević-Mitić O. Vesna
teaching professor/s: Milošević-Mitić O. Vesna
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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. Displacement equations, compatibility equations, equations of equilibrium. Energy balance. Entropy balance. Free energy. Constitutive relations. The coefficients of elasticity. Lame's constants. Generalized equation of heat conduction. The system of equations of the coupled dynamic thermoelastic problem. The boundary conditions, thermal and mechanical. Plane state of stress. Linear theory of thin thermoelastic plates.

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

lecture hours of active teaching: 35

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
responsible/holder professor: Anđelić M. Nina
teaching professor/s: Anđelić M. Nina
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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 thun-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
Introductory explanations. Torsion bars of arbitrary cross-section. Shear stress. Angle of twist. Out of plane deformation of cross-section. Compound arbitrary cross-section. The rectangular cross-section. Thin rectangular cross-section. Membrane analogy. Basic Theory of thin-walled structural elements. Unconstrained and constrained torsion. Thin-walled open cross-sections. Stresses and strains in unconstrained torsion. The concept of sectoral coordinates. Sectoral geometric characteristics of the cross-section. Main sector coordinators. Shear center. Constrained torsion. Bimoment. Stresses and strains in constrained torsion. Differential equations of the angle of twist. The general case of stress. Thin-walled elements closed cross-sections. Celled sections. Multicellular sections. Bending of compressed beams. Exact solution. Approximate solution. Beam with initial deflection. Bending of thin plates. Differential equations of thin plate bent. Different contour conditions. Thin rectangular plate. Arbitrary load.

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.

lecture hours of active teaching: 35

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. Anđelić, V. Milošević-Mitić: Strength of matherials-Tables, University of Belgrade, Faculty of Mechanical Engineering, Belgrade, 2015

N. Anđelić, V. Milošević-Mitić, M. Milovančević (in Serbian): Fundamentals of Strength of Structures (in Serbian), University of Belgrade, Faculty of Mechanical Engineering, Belgrade, 2019

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
responsible/holder professor: Miloš V. Marko
teaching professor/s: Miloš V. Marko
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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.

lecture hours of active teaching: 35

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
responsible/holder professor: Miloš V. Marko
teaching professor/s: Miloš V. Marko
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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 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, (optional) visiting to:

1. Military Technical Institute – Solid Propelant Rocket Motor Laboratory
2. Department of Automatic Control of 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, romm equipped with computers & software for design and simulations, labs, handouts.

lecture hours of active teaching: 35

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
responsible/holder professor: Petrović V. Milan
teaching professor/s: Petrović V. Milan
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Closed, open and isolated systems. State, equilibrium, process and properties, thermodynamic Cycles. Energy, energy Transfer. The first law of thermodynamics. Energy analysis of closed systems. Mass and energy analysis of open systems. The second law of thermodynamics, entropy. Work potential, exergy. Exergy Balances. Gas turbine power cycles. Thermodynamic improvement of gas turbine cycles. Steam turbine power cycles. Thermodynamic improvement of gas turbine cycles. Combined power cycles.

practical teaching
Exercises.

prerequisite
PhD Student - Thermal power enegineering

learning resources
Literature, computing facility

lecture hours of active teaching: 35

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

M. Moran, H. Shapiro: Fundamentals of Engineering Thermodynamics, Wiley, 2007.
Y. A. Cengel and M. A. Boles: Thermodynamics: an Engineering Approach, McGraw Hill, 2006.
H. D. Baehr, S. Kabelac: Thermodynamik: Grundlagen Und Technische Anwendungen
A. Bejan, Advanced Engineering Thermodynamics, 3rd ed., Wiley, 2006.

Tribology of machine elements

ID: PhD-3148
responsible/holder professor: Marinković B. Aleksandar
teaching professor/s: Lazović-Kapor M. Tatjana, Marinković B. Aleksandar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
ECTS credits: 5
final exam: written+oral

goals
To familiarize PhD engineering students with basic concepts of tribology, this would be useful in explaining and enhancing main processes and performances of various machine elements. An objective of the course is to present students crucial need and necessity of taking tribological aspects in design process of machine elements, mechanical systems development and for design in general. Introducing in methodology, procedures and requested tools in aim to organize and conduct corresponding tribology experimental investigations on some typical machine elements.

learning outcomes
Students who are attending to finish this course shall determine the general tribological phenomena and their application in the operation of typical machine elements. In accordance with the available equipment and facilities in laboratory they will introduce methods, types and elements needed for the implementation of the experimental research of machine elements, with emphasis on the creation of data acquisition using NI SCC module and transmitted the necessary software for data acquisition.

theoretical teaching
Introduction, of course, and summarize the basic concepts and phenomena in the field of tribology. The reasons for the necessity of consideration of tribological phenomena in the research and development of individual machine elements and systems. Introduction to Tribological Failure Analysis, Wear Analysis Process with Wear Mechanisms, Surface Examination and Characterisation, Contact Mechanics, Roughness, hardness, friction, Wear Testing; Properties of Lubricants; Lubrication Regimes with analysis; Design of Machine elements from aspect of Lubricants; Hydrodynamic Lubrication (Reynold's Equation, Fluid and Pad Bearings, Plain Journal Bearings), Elasto-hydrodynamic Lubrication; Design requirements of ceramic and composite sliding contacts, wear and friction behaviour of alumina composites with silicon carbide and graphite as solid lubricants.

practical teaching
Introductory lesson. The concept of training on the subject. Getting to know the Machine design Department lab for mechanical elements investigation with the available equipment and the acquisition of data for experimental research. Types of equipment for data acquisition with the necessary elements. Dating with portable data acquisition system (NI SCC). Demonstration and practice of measuring temperature, stress and strain of machine elements.

prerequisite
should be useful in case of previous finishing course "Experiments and simulations" at MSc studies at group for Design in mechanical engineering (DUM)

learning resources
available literature in form of books and International tribology conferences Proceedings, such as testing machines in laboratory for Machine elements (self lubricating sliding bearings, rolling bearings and gears)

lecture hours of active teaching: 35

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

Tribological Design of Machine Elements; D. Dowson, C.M. Taylor, M. Godet , D. Berthe
Tribology by I Hutchings, Edward Arnold
Engineering Tribology by Stachowiak & Batchelor, Butterworth-Heinnemann
Proceedings from International Conferences in tribology (WTC, ECOTRIB, Tribology Colloquium...)

Turbomachinery Flow Phenomena - Computational Fluid Dynamics

ID: PhD-3193
responsible/holder professor: Nedeljković S. Miloš
teaching professor/s: Nedeljković S. Miloš
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Three-dimensional non-viscous cascade flow – methods for solution in meridional section, blade-to-blade solution methods, sombined solutions, numerical solution of Euler equations system. Three-dimensional quasi-viscous calculations – application of boundary layer theory, secondary flow and vorticity, combined vorticity model, correction taking in account the losses. Calculation of spatial viscous flow in cascades – turbulent modeling, implicit and explicit procedures, pressure correction methods, artificial compressibility method.

practical teaching
Numerical exercises when needed

prerequisite
Knowledge of turbomachinery advanced courses, numerical methods, algorithms and programming.

learning resources
-

lecture hours of active teaching: 35

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
Lakshminarayana B. Fluid Dynamics and Heat Transfer of Turbomachinery. John Wiley & Sons Inc., New York, 1996.
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
responsible/holder professor: Nedeljković S. Miloš
teaching professor/s: Nedeljković S. Miloš
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
ECTS credits: 5
final exam: seminar works

goals
Mastering calculation methods of turbomachinery design.

learning outcomes
Mastering calculation methods of turbomachinery design.

theoretical teaching
One-dimensional (line) calculations – lifting surfaces and Wienig0Eckert methods for axial cascades, calculation of circular (radial) cascades. Non-viscous two-dimensional calculation theories – conformal mapping (complex potential, transformation, calculation), panel method, method of singularities, velocity hodograph.

practical teaching
practical design example

prerequisite
Knowledge of turbomachinery advanced courses, numerical methods, algorithms and programming.

learning resources
-

lecture hours of active teaching: 35

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
Степанов ГО. Гидродинамика решеток турбомашин. Физматгиз, Москва, 1962.
Dixon Sl. Fluid Mechanics, Thermodynamics of Tubomachinery. 3rd ed. Pergamon Press, Oxford, 1978.

Turbulence in turbomachinery

ID: PhD-3596
responsible/holder professor: Čantrak S. Đorđe
teaching professor/s: Čantrak S. Đorđe
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
ECTS credits: 5
final exam: oral

goals
The goal of this course is to introduce students in turbulence phenomena with focus on turbomachinery. The prediction of turbulent flows in internal and external aero- and hydrodynamics, as well as in many branches of engineering, is a complex problem. Compressible and non-compressible rotational flows occur in various types of turbomachinery. Vortex structures are formed in turbomachinery, before and following them. In this course will be presented various theoretical, experimental and numerical approaches for these complex investigations. Experimental techniques, such as laser Doppler velocimetry (LDV) and particle image velocimetry (PIV), are deeply correlated to the physical understanding of Reynolds equations and necessity for turbulence modeling.

learning outcomes
Knowledge on energy exchange processes in turbomachinery, turbulence fluid flow phenomena and various generated vortex structures in turbomachinery are crucial for scientific research in the field of energy. Knowledge on various turbulent models. Knowledge about experimental methods in turbomachinery.

theoretical teaching
Nature of turbulent flows, statistical and spectral description of turbulence. Kolmogorov's hypothesis. Identification of the coherent structures. Spatial and temporal scales of turbulent flows. Data processing - turbulence statistics. Reynolds averaged equations and calculation of the stresses, turbulent kinetic energy and kinetic energy dissipation. Basics of turbulent swirl jet behind the axial fan. Wall bounded flows and turbulent swirl flow in pipe. Turbulence models for studying the turbulence phenomena in turbomachinery.

practical teaching
1. PIV and/or LDV measurement equipment and some possible measurements.

2. Application of various turbulence models.

prerequisite
Familiarity with fluid mechanics, turbomachinery and turbulence.

learning resources
1. Textbooks listed in the references.

2. Lecture handouts.

3. Scientific papers.

3. Experimental test rigs and equipment in the Laboratory for hydraulic machinery and energy systems.

lecture hours of active teaching: 35

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

Tennekes H., Lumley J. L. (1972): A First Course in Turbulence, The MIT Press.
Davidson P. A. (2004): Turbulence, An Introduction for Scientists and Engineers, Oxford University Press.
Bradshaw P. (1971, reprint 1985): An Introduction to Turbulence and Its Measurement, Pergamon Press.
Panton R. L. (2013): Incompressible flow, 4th edition, Wiley.
Pope S. B. (2000): Turbulent flows, Cambridge Univ. Press.

Turbulent flow measurements

ID: PhD-3409
responsible/holder professor: Čantrak S. Đorđe
teaching professor/s: Janković Z. Novica, Čantrak S. Đorđe
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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

Measurement of flow parameters of incompressible and compressible flow with classical measuring techniques. Measurement of the turbulent flow field characteristics. Statistical measurement data processing and analysis. Temporal and space resolutions of flow and measuring system. Vorticity measurements. Time and space correlations. Hot-wire anemometers. Fluid flow visualization. Lasers in anemometry. Flow seeding. Lorenz-Mie theory. Measurement principles of Laser Doppler anemometry (LDA) and plane and stereo Particle image velocimetry (PIV). Construction, tests and adjustments of the Nd:Yag laser. Laser sheet optics. Stereo PIV calibration. Algortihms for data processing and validation. High speed stereo PIV or Time Resolved PIV. Types and architecture of used high speed cameras and lasers. Measurements in turbomachines.

practical teaching

1. Calibration of Conrad probe.

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.

6. Design, service and calibration of HWA probe.

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.

lecture hours of active teaching: 35

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

Ilić D. B., Čantrak Đ. S. (2017): Manual for fluid flow measurements in laboratory, Fac. of Mechanical Eng. Univ. of Belgrade, Belgrade. (in Serbian)
Vukoslavčević P., Petrović D. (2000): Multiple Hot-wire Probes - Measurements of Turbulent Velocity and Vorticity Vector Fields, Montenegrin Academy of Sciences and Arts, Podgorica.
Albrecht H.-E., Borys M., Damaschke N, Tropea C. (2003): Laser Doppler and Phase Doppler Measurement Techniques, Springer-Verlag, Berlin, Heidelberg.
Tropea C., Yarin A., Fosss J. (Eds.) (2007): Springer Handbook of Experimental Fluid Mechanics, Springer-Verlag, Berlin, Heidelberg.
Raffel M., Willert C. E., Scarano F., Kähler C. J., Wereley S. T., Kompenhans J. (2018): Particle Image Velocimetry, A Practical Guide, 3rd Ed., Springer International Publishing AG

Turbulent flows

ID: PhD-3138
responsible/holder professor: Lečić R. Milan
teaching professor/s: Lečić R. Milan, Ćoćić S. Aleksandar
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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
Physical characteristics and statistical nature of turbulence. Mathematical theory in turbulence. Reynolds statistics. Conservation equation in turbulent flows. Statistical characteristic of turbulence and their physical explanation. Structure of turbulent shear flows. Mechanism and calculation of turbulent transfer of momentum and heat in pipes and channels. Turbulent boundary layer. Turbulence structure and calculations of velocity and temperature field. Mechanism of momentum transfer in free turbulence. Calculation of two-dimensional and axisymmetric turbulent jets. Forces on the body immersed in turbulent stream. Calculations of drag and turbulent wake. Kinetic and spectral theory of turbulence.

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
-

lecture hours of active teaching: 35

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
Stephen Pope: Turbulent Flows, Cambridge University Press
Peter Davidson: Turbunce, an introduction for scientists and engineers, Oxford University Press

Vehicle Mechatronics - Special Chapters

ID: PhD-3217
responsible/holder professor: Popović M. Vladimir
teaching professor/s: Blagojević A. Ivan, Mitić R. Saša, Popović M. Vladimir
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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

lecture hours of active teaching: 35

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).
W. Bolton: Mechatronics, Prentice Hall, London, 2008.

Water waves

ID: PhD-3159
responsible/holder professor: Milićev S. Snežana
teaching professor/s: Milićev S. Snežana
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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.

lecture hours of active teaching: 35

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
responsible/holder professor: Motok D. Milorad
teaching professor/s: Motok D. Milorad
level of studies: Ph.D. (postgraduate) academic studies – Mechanical Engineering
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 cobined 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 doctorial studies.

learning resources
Commercial software in the field.

lecture hours of active teaching: 35

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
Jorgen Juncher Jensen: Load and Global Response of Ships, Technical University of Denmark, 2000
I. Dyer, R. Eatock Taylor, J.N. Newman, W.G. Price: Sea Loads on Ships and Offshore Structures, Cambridge University Press 1995.