FSB 100
100 Years of Faculty of Mechanical Engineering and Naval Architecture
University of Zagreb

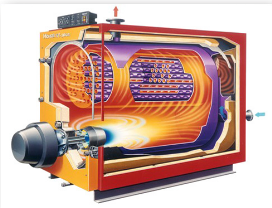
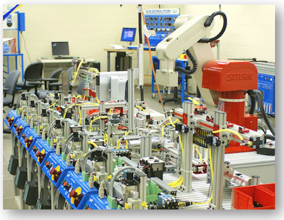
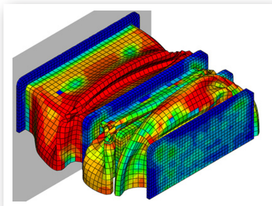
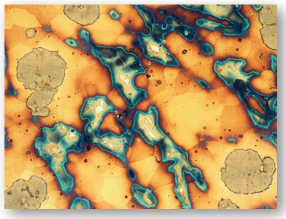
SVEUČILIŠTE U ZAGREBU
METALURŠKI FAKULTET
UNIVERSITY OF ZAGREB
FACULTY OF METALLURGY

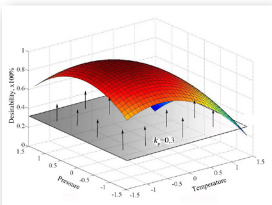
Doctoral Programme

Mechanical Engineering, Naval Architecture, Aeronautical Engineering, Metallurgical Engineering

2020/2021

Course Catalogue



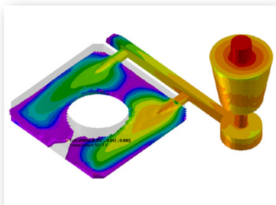
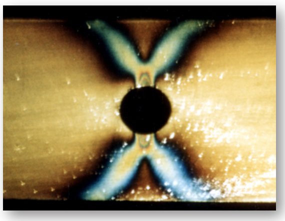
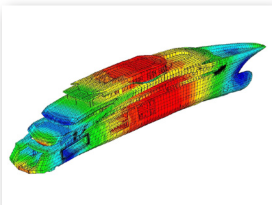
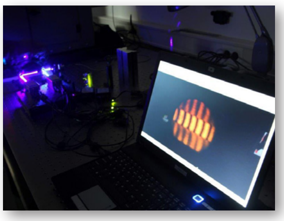





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Table of Contents

Study programme . . . 7
List of courses . . . 13
Level of support of the English language in the course . . . 19

Courses . . . 20
Introduction to scientific research . . . 21

Advanced Production Technologies . . . 22
Advanced Procedures of Primary Shaping . . . 24
Advanced Welding and Cutting Processes . . . 25
Modelling and Simulation of Forming and Machining Processes . . . 26
Adhesive Bonding in Fabrication . . . 27
Advanced Forming Processes . . . 28
Advanced Polymer Processing . . . 29
Automated Machinig Systems . . . 30
Corrosion Properties of Materials . . . 31
Corrosion Protection . . . 32
Failure Analysis . . . 33
High Efficiency Machining and Advanced Machine Tools . . . 34
Machining Systems Monitoring and Control . . . 35
Micro and Nanotechnology . . . 36
Modern Additive Manufacturing of Products . . . 37
Modern Machine Tools and Their Modules . . . 38
Modern Trends in Material Removal Processes . . . 39
Numerical Simulation of Metal Forming . . . 40
Robotization and Automation of Welding . . . 41
Simulation of Casting Processes . . . 42
Special Casting Procedures . . . 43
Underwater Welding and Cutting . . . 44

Aeronautical Engineering . . . 45
Continuum Mechanics . . . 47
Geometric Mechanics . . . 48
Computational Aerodynamics . . . 49
Fatigue and Fracture of Structures . . . 50
Mechanical Integrity of Structures . . . 51
Mechanics of Composite Structures . . . 52

Modelling, Control and Design of Wind Turbines . . . 53
Modelling, Simulation and Control of Flying Objects . . . 54
Rotary Wing Aeroelasticity . . . 55
Rotor Aerodynamics . . . 56
Selected Topics of Strength of Aeronautical Structures . . . 57

Computational Mechanics . . . 58
Continuum Mechanics . . . 60
Numerical Linear Algebra . . . 61
Advanced Methods of Numerical Analysis of Structures . . . 62
Biological Flows . . . 63
Computational Biomechanics . . . 64
Environmental Aerodynamics . . . 65
Fracture Mechanics, Damage and Fatigue . . . 66
Modelling from Macro- to NanoScale . . . 67
Numerical Methods of Nonlinear Analysis of Structures . . . 68
Structural Computational Dynamics . . . 69
Transport Phenomena . . . 70

Industrial Engineering and Management . . . 71
Numerical Linear Algebra . . . 73
Operations and Project Management . . . 74
Design and Analysis of Experiments . . . 75
Engineering Ethics and Social Responsibility . . . 76
Intelligent Information Systems . . . 77
Intelligent Process Planning . . . 78
Maintenance Management . . . 79
Operations Research in Logistics . . . 80
Quality Management . . . 81
Sustainable Production . . . 82

Materials Engineering . . . 83
Heat Treatment and Surface Engineering . . . 85
Materials Science and Engineering . . . 86
Modeling in Materials Research . . . 87
Advanced Metal Construction Materials . . . 88
Advanced Tool Materials . . . 89
Cellular Materials . . . 90
Composite materials . . . 91
Engineering Ceramics . . . 92

Functional Materials . . . 93
Materials and Environment . . . 94
Materials Selection and Product Development . . . 95
Mechanical Properties of Materials . . . 96
Methods of Materials Characterization . . . 97
Nanostructured Materials . . . 98
Polymer Materials . . . 99
Thermodynamic and Structure of Materials . . . 100
Tribology . . . 101

Mechatronics and Robotics . . . 102
Designing Mechatronic Systems . . . 104
Methods of Automatization . . . 105
Numerical Linear Algebra . . . 106
Robotics . . . 107
Advanced Computational Intelligence Systems . . . 108
Computational Intelligence Algorithms . . . 109
Digital Control Systems . . . 110
Distributed Control Systems . . . 111
Electrical Drives Control . . . 112
Hydraulics and Pneumatics – Selected Topics . . . 113
Intelligent Production Processes . . . 114
Learning Methods and Programming of Autonomous Robotic Systems . . . 115
Mobile Robots . . . 116
Nanorobotics . . . 117
Nonlinear Control Systems . . . 118
Optimization Techniques in Control . . . 119
Pneumatic and Hydraulic Servo Systems . . . 120
Scientific Cloud Computing . . . 121
Selected Topics of Computer Control . . . 122
Sensorics . . . 123

Metallurgical Engineering . . . 124
Advanced Physical Metallurgy . . . 126
Numerical Linear Algebra . . . 127
Solidification and As-cast Microstructure Evolution . . . 128
Theory of Metal Forming Process . . . 129
Advanced Methods of Metal Research . . . 130
Aluminum Alloy Casting . . . 131

Corrosion of structural steels . . . 132
Deformation Properties of Metals and Alloys . . . 133
Energy Efficiency of Industrial Furnaces . . . 134
Environmental Emissions from the Iron and Steel Metallurgy . . . 135
Innovative Processes of Metal Casting . . . 136
Leaching Processes in Hydrometalurgy . . . 137
Mathematical Modelling of Industrial Furnaces . . . 138
Metallurgy of Aluminum . . . 139
Metallurgy of Cast Irons and Steels . . . 140
Modern Methods of Chemical Analysis in Metallurgy . . . 141
Phase Transformations in Metallic Materials . . . 142
Special Alloys . . . 143
Theory of Metallurgical Processes . . . 144
Wastes and By-products of the Metallurgical Industry . . . 145
Welding Metallurgy . . . 146

Naval Architecture and Ocean Engineering . . . 147
Continuum Mechanics . . . 149
Equations of Mathematical Physics . . . 150
Mathematical Methods in Marine Hydrodynamics . . . 151
Numerical Linear Algebra . . . 152
Advanced Methods for Ship Structures Modelling and Analysis . . . 153
Advanced Methods of Fatigue Assessment of Welded Ship Structures . . . 154
CFD in Ship Design . . . 155
Design of Marine Propulsion Systems . . . 156
Effects of In-built Material Properties on As-built Ships . . . 157
Feasibility and Reliability in Structural Design . . . 158
Hydroelasticity of Ships and Marine Structures . . . 159
Multi-Criteria Models for Ship Concept Design . . . 160
Multi-Criteria Optimization of Thin-Walled Structures . . . 161
Offshore Structure Loading . . . 162
Probabilistic Approach to Damage Stability . . . 163
Profitable Ship Design . . . 164
Ship Propulsion System Vibrations . . . 165
Shipbuilding Management . . . 166
Shipbuilding Production Process Methods and Systems . . . 167
Ships Collisions and Groundings . . . 168
Simulation and Analytic Methods in Reliability of Marine Objects . . . 169

Stochastic Modelling of Loads of Ship Structures 170
Structual Safety 171
Theory of Seakeeping and Manoeuvrability 172

Process and Energy Engineering 173
Heat and Mass Transfer 175
Advanced Control for Energy Efficiency and Demand Response in Smart Grids 176
Advanced Quantitative Infrared Thermography 177
Advanced Thermal Measurements 178
Computational Fluid Dynamics 179
Cooling-Heating Processes with Heat Pumps 180
Development of Modern Thermal Power Plants 181
Dynamics and Control of Thermo-Hydraulic Processes 182
Energy and Environmental Protection 183
Energy Planning Methods 184
Evaporative Devices 185
Experimental Methods in Heat and Mass Transfer 186
Mesuremnt and Calibration Systems 187
Methods for Useful Life Estimation of Power Equipment and Machines 188
Metrology of Heat and Process Quantities 189
Modelling and Approximation in Heat and Mass Transfer Processes 190
Modelling of Combustion and Radiative Heat Transfer 191
Numerical Methods in Heat Transfer 192
Numerical Simulations in Energy Conversion Processes 193
Selected Chapters from the Theory of Turbomachines 194
Storage of Thermal Energy in Buildings and Industry 195
The Flow, Thermal and Mechanical Phenomena in Turbomachines 196
Thermal Apparatus and Equipment 197
Transients in Pipelines 198
Wind and Structures 199

Scientific Metrology 200
Advanced Statistical Methods in Metrology 202
Fundamental Metrology 203
Numerical Linear Algebra 204
Dimensional Measurements – Advanced Methods 205
Dimensional Nanometrology 206
Measuring of Force and Hardness 207
Methods for Estimating Measurement Uncertainty 208

Metrology of Heat and Process Quantities ... 209
Nondestructive Evaluation Methods ... 210
Physical Principles of Metrological Instruments and Microscopy ... 211

Theory of Structures ... 212
Dynamic of Machines ... 214
Equations of Mathematical Physics ... 215
Numerical Linear Algebra ... 216
Theory of Elasticity ... 217
Alternative Drives of Motor Vehicles ... 218
Biomechanics ... 219
Complex Socio-Technical Systems ... 220
Computationally Supported Development of the ICE and Vehicles ... 221
Data Management in Product Development – PLM ... 222
Design of High Strength Joints ... 223
Design Theories ... 224
Engines and Vehicles – Selected Topics ... 225
Experimental Model Techniques ... 226
Investigation of Thermal Processes in the IC Engine ... 227
Nonlinear Dynamics ... 228
Optical Methods of Mechanics ... 229
Sliding-Rolling Contacts ... 230
Theory of Gearing ... 231
Theory of Plasticity ... 232
Theory of Viscoelasticity ... 233
Vibrations of Systems with Clearances ... 234

Lecturers ... 235

Study programme

General information about the doctoral study programme

Name of the doctoral study: Mechanical Engineering, Naval Architecture, Aeronautical Engineering, Metallurgical Engineering

Provider of the study programme: University of Zagreb, Faculty of Mechanical Engineering and Naval Architecture University of Zagreb

Implementer of the study: University of Zagreb, Faculty of Mechanical Engineering and Naval Architecture University of Zagreb, Faculty of Metallurgy

Science area: Technical science

Fields: Mechanical Engineering
Naval Architecture
Aeronautical Engineering, Rocket and Space Technology
Basic Technical Science
Metallurgy

Admissions

For admission to the Doctoral Study Programme in Mechanical Engineering, Naval Architecture, Aeronautical Engineering and Metallurgical Engineering the applicant must have completed the respective university graduate study programme of Mechanical Engineering, Naval Architecture or Aeronautical Engineering with an average grade earned at the undergraduate and graduate level above 3.50 and a total of 300 ECTS credits, that is, the equivalent grade obtained through other systems of evaluation. Admission may be granted also to graduates who have obtained a degree in other scientific fields, possibly with prescribed number of differential exams to be taken in order to acquire the basic knowledge necessary for attending and completing the study programme.

The criteria for evaluation of applicants include the educational attainment during graduate studies, proved interest in scientific research, number of papers published, referrals by professors and potential mentor as well as proposal of the area of research. An interview with the applicant as a prerequisite of the enrolment procedure.

Duration of the doctoral study

A doctoral candidate has a right to finalize the doctoral study within eight years, under the same conditions as defined during his/her enrollment. Periods when the candidate is disabled to work and fulfill his/her obligations on the doctoral study (e.g., pregnancy, parental leave, long term illness) is not accounted for in the eight-year period. The period of eight years can be extended, if there are justified reasons for that. Postgraduate Studies Committee evaluates request for extension and is responsible for making a decision regarding the extension.

Requirements for completion of the doctoral study

The Doctoral study is completed when all prescribed obligations are fulfilled and the dissertation is drawn up and presented in public. The necessary requirements for defending the dissertation are a total of 120 ECTS credits earned, 1 CC paper related to the doctoral research with a minimum of 20 ECTS credits (in which the candidate is the only one or one of the main authors) published (or approved for publication), 2 international conferences attended and 2 presentations delivered at the doctoral candidates' workshop.

The academic title conferred upon a student who has successfully completed the doctoral study and defended his/her dissertation is Doctor of Technical Science (abbreviated: dr.sc.) in a particular field.

Structure and organization of the doctoral study programme

This multidisciplinary doctoral study in terms of teaching and research is organized in 11 modules, which are givan in the following table. All modules are presented by research topics linked to the proposed fundamental elective and elective courses of the module.

NAME OF THE MODULE	RESEARCH TOPICS COVERED BY THE MODULE
Advanced Production Technologies	Advanced Processes and Systems in Metal Forming Corrosion of Metallic Materials and Protection Methods Primary Shaping and Forming Welding Processes and Equipment Casting and Moulding Processes Advanced Machining Systems and Processes
Aeronautical Engineering	Aeronautical Engineering
Computational Mechanics	Strength and Reliability of Mechanical Systems Modelling of Fluid Flow and Thermal Systems Modelling of Biological Systems
Industrial Engineering and Management	Production and Sustainable Development Maintenance Logistics and Supply Chain Management Quality Assurance Apply Statistic and Design of Experiments
Materials Engineering	Characterization and Testing of Materials Modelling in Materials Research Materials Development Nanostructured Materials and Nanotechnologies Heat Treatment and Surface Engineering Tribology
Mechatronics and Robotics	Mechatronics Robotics Control Theory Artificial Intelligence and Computer Science Pneumatics and Hydraulics Social Conditioning of Automation

NAME OF THE MODULE	RESEARCH TOPICS COVERED BY THE MODULE
Metallurgical Engineering	Metallurgy of Steel, Ferrous and Coloured Metals Shaping of Materials by Deformation Production, Design and Characterization of Metallic Materials Energy Efficiency of Metallurgical Processes Physical Metallurgy Industrial Ecology
Naval Architecture and Ocean Engineering	Marine Hydrodynamics Marine Structures Ship Production Engineering Ship Design Marine Power Systems
Process and Energy Engineering	Heat and Mass Transfer Process and Energy Engineering Energy Management Environmental Engineering Engineering Modeling and Computer Simulations
Scientific Metrology	Length Metrology Nanometrology Metrology of Heat and Process Quantities Force Metrology Statistical Modelling in Metrology Nondestructive Evaluation
Theory of Structures	Mechanics of Solids and Structures Development of Motor Vehicles and Mechanical Handling Equipment Power and Movement Transmission Theory Tribology of Mechanical Elements Product development

Each doctoral candidate must pass a total of 6 courses as follows: Introduction to scientific research, 1 fundamental elective course of the module, 4 elective courses of the module.

The module's fundamental course or fundamental elective course is the course that more broadly defines the topic of research. The doctoral candidate chooses a module at enrolment and if the module has more than one fundamental course, he/she chooses one. The module's fundamental course is worth 6 ECTS points (45 hours of lectures).

The module's elective courses are courses offered to the doctoral candidate in his/her specific research topic. The module's elective courses are worth 6 ECTS points each. The doctoral candidate chooses elective courses in agreement with the mentor and the module head, as a rule between the module's elective courses and the module's fundamental elective courses.

With permission of the module head, the doctoral candidate may enrol into a course from another doctoral study module or a non-attended course from the doctoral study. With permission of the both the module head and the Committee, it is possible to enrol into courses from other institutions. By attending elective courses a maximum of 24 ECTS credits can be earned.

Conditions for advancement and submission of the dissertation are based on the ECTS system of evaluation of the doctoral student's overall performance concerning single courses or other activities during studies, whereby each course or activity is assigned a certain number of ECTS points (credits) in proportion to the doctoral candidate's workload (1 ECTS = 25 to 30 hours of work).

The remaining ECTS points are used to define minimum requirements in the obtained scientific results and are used as a flexible evaluation tool of achieved results, rather than a measure of a workload defined in terms of time. The doctoral candidate obtains ECTS credits by sitting for exams, publicly defending his/her own or verified research theoretical or experimental papers, research-related international mobility, participating as a speaker at a scientific conference, doctoral workshop, science festival or exhibition, attending summer schools and similar teaching forms in the field of research, industry-related research, publicly defending his/her dissertation theme, submission and acceptance of papers for publishing in an international review journal, i.e., in the conference proceedings at an internationally recognized conference, recognition of patents, and other forms under the proposed programme.

Advising and guiding doctoral students through the doctoral study

On proposal of the doctoral candidate and with consent of the potential mentor, the doctoral candidate is assigned a mentor appointed by the Postgraduate Studies Committee during enrolment or the first year of study, at the latest within three months after submitting the dissertation topic. If a potential mentor has not been established during admission, the doctoral candidate is assigned an academic adviser by the Postgraduate Studies Committee, who helps him/her in choosing and defending the dissertation topic and monitors his/her work and progress up until a mentor is nominated.

Regular fulfilment of obligations related to research, cooperation on national and international projects, industry-related research, international mobility and publications is confirmed by the academic adviser or mentor by signing the student's record book.

The mentor is obliged to guide the doctoral student in drawing up the dissertation, monitor the quality of the doctoral student's performance, promote the publishing of his/her papers and enable participation on scientific projects. Once a year, the mentor shall submit a report on the doctoral student's activities to the Faculty Council on a form prescribed by the University. Prior to the appointment of a mentor, the report is submitted by the academic adviser. If there is more than one mentor, each of them undertakes the responsibility for the part of the research and dissertation writing procedure that needs to be determined in advance.

Once a year, the doctoral student submits to the Postgraduate Studies Committee an activities report on a form prescribed by the University. Should the doctoral student quality of performance assessed through annual evaluation procedures conducted by the Postgraduate Studies Committee be unsatisfactory, the Faculty Council may, on proposal of the Committee, decide that the doctoral student should loose the right to continue his/her studies.

Quality assurance

Quality indicators of doctoral study programme are: scientific production of teachers and doctoral students, quality of instruction, relevance and quality of doctoral dissertations, statistical data on duration of study, statistical data on numbers of new holders of doctoral degrees in relation to the number of doctoral students annually, international cooperation realized, mobility of doctoral students, employability of new holders of doctoral degrees.

The realisation of the postgraduate study programme is monitored and coordinated by the Postgraduate Studies Committee that reports to the Faculty Council. All heads of the doctoral study modules take part in the Committee's activities. Once a year, doctoral students and industry are surveyed for the purpose of collecting information on the level of satisfaction with the doctoral study and potential for improvement.

Tuition and costs

The costs of doctoral studies include tuition costs and costs related to research, publishing, defending of the dissertation topic, making of the thesis and thesis defense. Tuition costs are paid every semester at admission. Should the doctoral candidate withdraw from the doctoral study once it has begun, the doctoral candidate, i.e., the payer of tuition fees, is not entitled to reimbursement. Tuition fees and dissertation fees are set by the Faculty in accordance with the Statute of the Faculty.

List of courses

Remark: all courses are worth 6 ECTS points.

Course title	Eng. Lev.	Sem.
Adhesive Bonding in Fabrication	R3	2. i 3.
Advanced Computational Intelligence Systems	R3	2. i 3.
Advanced Control for Energy Efficiency and Demand Response in Smart Grids	R3	2. i 3.
Advanced Forming Processes	R2	2. i 3.
Advanced Metal Construction Materials	R2	2. i 3.
Advanced Methods for Ship Structures Modeling and Analysis	R3	2. i 3.
Advanced Methods of Fatigue Assessment of Welded Ship Structures	R3	2. i 3.
Advanced Methods of Numerical Analysis of Structures	R3	2. i 3.
Advanced Methods of Numerical Analysis of Structures	R3	2. i 3.
Advanced Physical Metallurgy	R2	1.
Advanced Polymer Processing	R2	2. i 3.
Advanced Procedures of Primary Shaping	R2	1.
Advanced Quantitative Infrared Thermography	R2	2. i 3.
Advanced Statistical Methods in Metrology	R3	1.
Advanced Thermal Measurements	R3	2. i 3.
Advanced Tool Materials	R2	2. i 3.
Advanced Welding and Cutting Processes	R3	1.
Alternative Drives of Motor Vehicles	R2	2. i 3.
Aluminium Alloys Casting	R3	2. i 3.
Automated Machining Systems	R2	2. i 3.
Biological Flows	R2	2. i 3.
Biomechanics	R1	2. i 3.
Cellular Materials	R2	2. i 3.
CFD in Ship Design	R3	2. i 3.
Complex Socio-Technical Systems	R3	2. i 3.
Composites	R1	2. i 3.
Computational Aerodynamics	R3	2. i 3.
Computational Biomechanics	R3	2. i 3.

Course title	Eng. Lev.	Sem.
Computational Fluid Dynamics	R2	2. i 3.
Computational Intelligence Algorithms	R3	2. i 3.
Computationally Supported Development of the ICE and Vehicles	R3	2. i 3.
Continuum Mechanics	R3	1.
Cooling-Heating Processes with Heat Pumps	R3	2. i 3.
Corrosion of Structural Steels	R2	2. i 3.
Corrosion Properties of Materials	R1	2. i 3.
Corrosion Protection	R1	2. i 3.
Data Management in Product Development - PLM	R1	2. i 3.
Deformation Properties of Metals and Alloys	R2	2. i 3.
Design and Analysis of Experiments	R3	2. i 3.
Design of High Strength Joints	R3	2. i 3.
Design of Marine Propulsion Systems	R3	2. i 3.
Design Theories	R3	2. i 3.
Designing Mechatronic Systems	R1	1.
Development of Modern Thermal Power Plants	R2	2. i 3.
Digital Control Systems	R1	2. i 3.
Dimensional Measurements - Advanced Methods	R3	2. i 3.
Dimensional Nanometrology	R3	2. i 3.
Distributed Control Systems	R3	2. i 3.
Dynamic of Machines	R1	1.
Dynamics and Control of Thermo-Hydraulic Processes	R3	2. i 3.
Effects of In-built Material Properties on As-built Ships	R3	2. i 3.
Electrical Drives Control	R2	2. i 3.
Energy and Environmental Protection	R3	2. i 3.
Energy Efficiency of Industrial Furnaces	R2	2. i 3.
Energy Planning Methods	R3	2. i 3.
Engineering Ceramics	R2	2. i 3.
Engineering Ethics and Social Responsibility	R2	2. i 3.
Engines and Vehicles - Selected Topics	R2	2. i 3.
Environmental Aerodynamics	R3	2. i 3.

Course title	Eng. Lev.	Sem.
Environmental Emissions from Iron and Steel Metallurgy	R2	2. i 3.
Equations of Mathematical Physics	R3	1.
Evaporative Devices	R0	2. i 3.
Experimental Methods in Heat and Mass Transfer	R2	2. i 3.
Experimental Model Techniques	R2	2. i 3.
Failure Analysis	R1	2. i 3.
Fatigue and Fracture of Structures	R3	2. i 3.
Feasibility and Reliability in Structural Design	R3	2. i 3.
Fracture Mechanics, Damage and Fatigue	R3	2. i 3.
Functional Materials	R2	2. i 3.
Fundamental Metrology	R3	1.
Geometric Mechanics	R3	1.
Heat and Mass Transfer	R1	1.
Heat Treatment and Surface Engineering	R2	1.
High Efficiency Machining and Advanced Machine Tools	R2	2. i 3.
Hydraulics and Pneumatics - Selected Topics	R2	2. i 3.
Hydroelasticity of Ships and Marine Structures	R3	2. i 3.
Innovative Processes of Metal Casting	R3	2. i 3.
Intelligent Information Systems	R1	2. i 3.
Intelligent Process Planning	R1	2. i 3.
Intelligent Production Processes	R2	2. i 3.
Investigation of Thermal Processes in the IC Engine	R3	2. i 3.
Leaching Processes in Hydrometallurgy	R2	2. i 3.
Learning Methods and Programming of Autonomous Robotic Systems	R1	2. i 3.
Machining Systems Monitoring and Control	R1	2. i 3.
Maintenance Management	R1	2. i 3.
Materials and Environment	R3	2. i 3.
Materials Science and Engineering	R2	1.
Materials Selection and Product Development	R3	2. i 3.
Mathematical Methods in Marine Hydrodynamics	R3	1.
Mathematical Modelling of Industrial Furnaces	R2	2. i 3.

Course title	Eng. Lev.	Sem.
Measuring of Force and Hardness	R3	2. i 3.
Mechanical Integrity of Structures	R3	2. i 3.
Mechanical Properties of Materials	R1	2. i 3.
Mechanics of Composite Structures	R3	2. i 3.
Mesuremnt and Calibration Systems	R3	2. i 3.
Metallurgy of Aluminium	R2	2. i 3.
Metallurgy of Cast Irons and Steels	R0	2. i 3.
Methods for Estimating Measurement Uncertainty	R3	2. i 3.
Methods for Useful Life Estimation of Power Equipment and Machines	R3	2. i 3.
Methods of Automatization	R1	1.
Methods of Materials Characterization	R1	2. i 3.
Metrology of Heat and Process Quantities	R3	2. i 3.
Micro and Nanotechnology	R2	2. i 3.
Mobile Robots	R2	2. i 3.
Modelling and Approximation in Heat and Mass Transfer Processes	R3	2. i 3.
Modelling and Simulation of Forming and Machining Processes	R2	1.
Modelling from Macro- to Nano-Scale	R3	2. i 3.
Modelling in Materials Research	R2	1.
Modelling of Combustion and Radiative Heat Transfer	R3	2. i 3.
Modelling, Control and Design of Wind Turbines	R3	2. i 3.
Modelling, Simulation and Control of Flying Objects	R2	2. i 3.
Modern Additive Manufacturing of Products	R2	2. i 3.
Modern Machine Tools and Their Modules	R2	2. i 3.
Modern Methods of Chemical Analysis in Metallurgy	R0	2. i 3.
Modern Trends in Material Removal Processes	R2	2. i 3.
Multi-Criteria Models for Ship Concept Design	R0	2. i 3.
Multi-Criteria Optimization of Thin-Walled Structures	R3	2. i 3.
Nanorobotics	R3	2. i 3.
Nanostructured Materials	R2	2. i 3.
Nondestructive Evaluation Methods	R3	2. i 3.
Nonlinear Control Systems	R1	2. i 3.

Course title	Eng. Lev.	Sem.
Nonlinear Dynamics	R1	2. i 3.
Numerical Linear Algebra	R2	1.
Numerical Methods in Heat Transfer	R3	2. i 3.
Numerical Methods of Nonlinear Analysis of Structures	R3	2. i 3.
Numerical Simulation of Metal Forming	R2	2. i 3.
Numerical Simulations in Energy Conversion Processes	R2	2. i 3.
Offshore Structure Loading	R3	2. i 3.
Operations and Projects Management	R3	1.
Operations Research in Logistics	R1	2. i 3.
Optical Methods of Mechanics	R2	2. i 3.
Optimization Techniques in Control	R3	2. i 3.
Phase Transformations in Metallic Materials	R2	2. i 3.
Physical Principles of Metrological Instruments and Microscopy	R3	2. i 3.
Pneumatic and Hydraulic Servo Systems	R2	2. i 3.
Polymer Materials	R3	2. i 3.
Probabilistic Approach to Damage Stability	R3	2. i 3.
Profitable Ship Design	R3	2. i 3.
Quality Management	R3	2. i 3.
Robotics	R2	1.
Robotization and Automation of Welding	R3	2. i 3.
Rotary Wing Aeroelasticity	R3	2. i 3.
Rotor Aerodynamics	R2	2. i 3.
Scientific Cloud Computing	R3	2. i 3.
Selected Chapters from the Theory of Turbomachines	R3	2. i 3.
Selected Topics of Computer Control	R1	2. i 3.
Selected Topics of Strength of Aeronautical Structures	R3	2. i 3.
Sensorics	R1	2. i 3.
Ship Propulsion System Vibrations	R3	2. i 3.
Shipbuilding Management	R3	2. i 3.
Shipbuilding Production Process Methods and Systems	R3	2. i 3.
Ships Collisions and Groundings	R3	2. i 3.

Course title	Eng. Lev.	Sem.
Simulation and Analytic Methods in Reliability of Marine Objects	R3	2. i 3.
Simulation of Casting Processes	R2	2. i 3.
Sliding-Rolling Contacts	R2	2. i 3.
Solidification and As-cast Microstructure Evolution	R3	1.
Special Alloys	R2	2. i 3.
Special Casting Procedures	R0	2. i 3.
Stochastic Modelling of Loads of Ship Structures	R3	2. i 3.
Storage of Thermal Energy in Buildings and Industry	R3	2. i 3.
Structural Computational Dynamics	R1	2. i 3.
Structural Safety	R3	2. i 3.
Sustainable Production	R1	2. i 3.
The Flow, Thermal and Mechanical Phenomena in Turbomachines	R3	2. i 3.
Theory of Elasticity	R2	1.
Theory of Gearing	R2	2. i 3.
Theory of Metal Forming Process	R2	1.
Theory of Metallurgical Processes	R3	2. i 3.
Theory of Plasticity	R3	2. i 3.
Theory of Seakeeping and Manoeuvrability	R3	2. i 3.
Theory of Viscoelasticity	R1	2. i 3.
Thermal Apparatus and Equipment	R2	2. i 3.
Thermodynamic and Structure of Materials	R2	2. i 3.
Transients in Pipelines	R2	2. i 3.
Transport Phenomena	R1	2. i 3.
Tribology	R2	2. i 3.
Underwater Welding and Cutting	R3	2. i 3.
Vibrations of Systems with Clearances	R1	2. i 3.
Waste and By-Products from the Metallurgical Industry	R2	2. i 3.
Welding Metallurgy	R1	2. i 3.
Wind and Structures	R3	2. i 3.

Level of support of the English language in the course

The meaning of levels is as follows:

Level L0: The course is not offered in English.

Level L1: The course is given in the Croatian language in all its elements (lectures, assignments, exams), but foreign students who are assigned to a (mixed) Croatian group will be offered individual or group consultations (in English language) with the lecturers. The lecturers will refer the students to the teaching material and literature for the course in the English language and provide the course examination in the English language.

Level L2: With the consent of all students enrolled in the course, the lecturer will provide a subset of all course elements in the English language. In mixed English and Croatian language groups, teaching materials and examinations will be provided in both languages. Level 2 also includes consultations for foreign students (similar to level 1) to cover the teaching elements which are otherwise available only in the Croatian language.

Level L3: All elements of the course are given in English. This level also includes courses with separate groups of students according to the language of instruction (some groups receiving instruction only in the Croatian language, and some only in the English language).

Courses

Fundamental course, compulsory for all study modules

Introduction to scientific research

Course Description:

Understanding the difference between professional and research work, scientific problems, knowing how to review literature, use scientific databases, perform research, set the hypothesis, methods of proving the hypothesis: experimental, theoretical, analytical and numerical, visualise the results, perform error analysis and write research manuscript and project proposal.

Lecturers: Prof. Dubravko Majetić, Prof. Neven Duić, Prof. Joško Parunov, Prof. Zdravko Terze

Literature:

1. Anthony C. Winkler, Jo Ray McCuen-Metherell, Writing the Research Paper: A Handbook
2. Geraldine Woods, Research Papers For Dummies
3. Kate L. Turabian, Wayne C. Booth, Gregory G. Colomb, Joseph M. Williams, University of Chicago Press Staff, A Manual for Writers of Research Papers, Theses, and Dissertations, Seventh Edition: Chicago Style for Students and Researchers (Chicago Guides to Writing, Editing, and Publishing)
4. Ranjit Kumar, Research Methodology: A Step-by-Step Guide for Beginners
5. Anthony E. Kelly, Handbook of Design Research Methods in Education: Innovations in Science, Technology, Engineering, and Mathematics, Learning and Teaching
6. John Mandel, The Statistical Analysis of Experimental Data (Dover Books on Engineering)

ISVU Number: 155490

ECTS Credits: 6

Semester: winter

English Level: R3

Study module:

Advanced Production Technologies

List of fundamental elective courses of the doctoral study module:

1. Advanced Procedures of Primary Shaping
2. Advanced Welding and Cutting Processes
3. Modelling and Simulation Metal Forming and Machining Processes

List of elective courses of the doctoral study module:

1. Adhesive Bonding in Fabrication
2. Advanced Forming Processes
3. Advanced Polymer Processing
4. Automated Machining Systems
5. Corrosion Properties of Materials
6. Corrosion Protection
7. Failure Analysis
8. High Efficiency Machining and Advanced Machine Tools
9. Machining Systems Monitoring and Control
10. Micro and Nanotechnology
11. Modern Additive Manufacturing of Products
12. Modern Machine Tools and Their Modules
13. Modern Trends in Material Removal Processes
14. Numerical Simulation of Metal Forming
15. Robotization and Automation of Welding
16. Simulation of Casting Processes
17. Special Casting Methods
18. Underwater Welding and Cutting

Advanced Procedures of Primary Shaping

Course Description:

Acquiring expanded knowledge about advanced procedures of primary shaping of metals and polymer materials.

Lecturers: Prof. Branko Bauer, Prof. Mladen Šercer

Literature:

1. Raos, P., Šercer, M.: Teorijske osnove proizvodnje polimernih tvorevina, Strojarski fakultet u Slavonskom Brodu, Slavonski Brod/Zagreb, 2010.
2. Čatić, I., Johannaber, F.: Injekcijsko prešanje polimera i ostalih materijala, DPG, Zagreb, 2002.
3. Čatić, I.: Proizvodnja polimernih tvorevina, DPG, Zagreb, 2006.
4. Casting, ASM Handbook, Vol. 15, ASM International, 2008.
5. R. Roller et al, Fachkunde für giessereitechnische Berufe, Europa-Lehrmitel Verlag, 2009.

ISVU Number: 156108

ECTS Credits: 6

Semester: winter

English Level: R2

Advanced Welding and Cutting Processes

Course Description:

Some types of GTAW, GMAW and SAW welding, welding in a narrow groove, orbital welding, welding with hot and cold wire, tandem (multiple wires) welding. Plasma welding, cutting and drilling. Laser and electron beam welding, cutting and drilling. High frequency welding. Ultrasound welding. Explosion welding. Rotary arc welding. Underwater welding. Welding of plastics. Brazing, soldering and adhesive bonding. Principles of choosing the adequate welding technology. For every technology a principle of energy generation, influential parameters and practical examples are given. Different versions of basic technologies are given and explained. Practical demonstrations of welding and cutting.

Lecturers: Assoc. Prof. Ivica Garašić, Prof. Zoran Kožuh

Literature:

1. M.Beckert, A.Nevman: Grundlagen der Schweisstechnik, Berlin, 1986.
2. H.Huegel, F.Olsen, W.Steen, I.Bulabios, D.Kedemeir: Advanced Techniques, Part 2/2 Euro Laser Academy, 1994.
3. S.Kralj, T.Misir: Laserska tehnika, Inženjerski priručnik Praktičar, Školska knjiga, 1994.
4. Branko Bauer, "Optimiranje parametara laserskog zavarivanja čelika za poboljšavanje", Doktorska disertacija, FSB Zagreb, 1998.
5. Zlatko Glogović, "Utjecaj parametara plinskog naštrcavanja na svojstva nanešenog sloja", Doktorska disertacija, FSB Zagreb, 2010.

ISVU Number: 156140

ECTS Credits: 6

Semester: winter

English Level: R3

Modelling and Simulation of Forming and Machining Processes

Course Description:

Lecture includes technologies according to systematization in the frame of DIN 8580 norm, that defines the final form. It implies the technologies of shape changes by plastic deformation while retaining its mass and material cohesion, and technology of dividing i.e. local separation of material. Taking into account the close connection between these technologies, it is synergistically examined in the meaninig of process traceability. Special attention is put on computer modelling and simulation of technological processes, for the purpose to increase the level of automatization and flexibility of manufacturing process, The goal is to enable the students for integrated application of knowledge from both fields of technology and improve the production processes.

Lecturers: Prof. Toma Udiljak, Prof. Damir Ciglar

Literature:

1. G. Spur, T. Stoferle, Handbuch der Fertigungstechnik, Springer Verlaf, New York, 1984.
2. K. Lange, Lehrbuch der Umformtechnik. Springer Verlag, 1992.
3. P.M. Dixit, U. S. DixitModeling of Metal Forming and Machining Processes: by Finite Element and Soft Computing Methods (Engineering Materials and Processes), Springer 2008
4. M. Armendia, M. Ghassempouri, E. Ozturk, F. Peysson, Twin-Control- A Digital Twin Approach to Improve Machine Tools Lifecycle, Spinger, 2019

ISVU Number: 156096

ECTS Credits: 6

Semester: winter

English Level: R2

Adhesive Bonding in Fabrication

Course Description:

Theory of adhesive bonding. Mechanisms of adhesive bonding. List and classification of adhesives. Mechanism of solidification and its features and possibilities of application. Influential parameters in strength of adhesive joints. Types of load and their distribution in butt and overlap joints. Brittleness of bonded joints. Types of failures and analysis of bonded joints during mechanical load and environment conditions. Design of bonded joints. Rules for designing lap, T and pipe joints. Methods for calculating the strength of bonded joints. Analysis of choosing the right adhesive. Methods of joint preparation, safety measures. Testing of bonded joints. Examples of bonded joints.

Lecturer: Prof. Zoran Kožuh

Literature:

1. S. Žebić, Ž. Vilinčić: Ljepila, Tehnička enciklopedija, 1980, 7 knjiga, str 581-591
2. G. R. D. Adams, W. C. Wake: Structural Adhesive Joints in Engineering, Elsevier Applied Science Publishers, London, 1984
3. G. Habenicht: Kleben, Springer Verlag, Berlin, 1986
4. Zoran Kožuh, "Utjecaj eksploatacijskih uvjeta na čvrstoću lijepljenih spojeva",Doktorska disertacija, FSB Zagreb, 1998.

ISVU Number: 156142

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Advanced Forming Processes

Course Description:

Making acquaintance with the newest methods and production techniques in metal forming operations. The need for reindustrialization and revitalization of production is possible only by applying new knowledge and through that new and innovative technologies become the ones on which is based production in future in competitive circumstances. At the same time by comparison with classical production techniques the students are qualified for critical analysis and synthesis of new knowledge.

Lecturer: Asst. Prof. Zdenka Keran

Literature:

1. G. Spur, T. Stoferie: Handbuch ser Fertigungstechnik, Springer Verlag, Muenchen, 1994.

ISVU Number: 156101

ECTS Credits: 6

Semester: summer/winter

English Level: R2

Advanced Polymer Processing

Course Description:

To provide a more advanced understanding of polymer processing, through advanced analysis and modelling of plastics extrusion, injection moulding and other processes.

Lecturers: Assoc. Prof. Damir Godec, Prof. Mladen Šercer

Literature:

1. Progelhof, R.C., Throne, J.L.: Polymer Engineering Principles, Hanser Publishers, 1993.
2. Ćorić, D., Filetin, F.: Materijali u zrakoplovstvu, FSB, Zagreb, 2012.
3. Filetin, T. (ur): Suvremeni materijali i postupci, Hrvatsko društvo za materijale i tribologiju, Zagreb, 2005.
4. Avery, J.: Gas-Assist Injection Molding, Carl Hanser Verlag, Munich, 2001.
5. Šercer, Mladen; Barić, Gordana.
6. Suvremeni postupci prerade polimernih materijala // Suvremeni materijali i postupci / Filetin, Tomislav (ur.).

ISVU Number: 156109

ECTS Credits: 6

Semester: summer/winter

English Level: R2

Automated Machinig Systems

Course Description:

Control of machine tools (MT) and machining systems (MS). Flexible automation (FA) and numerical control (NC), DNC, ACC, ACO, CIM. Basic features of intelligent MT and intelligent MS (IMS). Biological manufacturing systems (BMS). Open architecture controllers. Integration with other equipment (tool presetting devices, robots, transport equipment, other CNC machines, storage and retrieval systems, ...). Multisensory techniques and systems. Conventional and intelligent sensors. Software for controllers, control units and programing techniques. Reconfigurable machining systems. Virtual machining systems and virtual manufacturing. Digital manufacturing and cyber physical factories. Autonomous and smart manufacturing.

Lecturers: Prof. Toma Udiljak

Literature:

1. Y. Altintas: Manufacturing Automation, Cambridge University Press, Cambridge, 2012
2. S.-H. Suh, S.-K. Kang, D.-H. Chung, I. Stroud: Theory and Design of CNC Systems, Springer-Verlag London Limited 2008

ISVU Number: 156117

ECTS Credits: 6

Semester: summer/winter

English Level: R2

Corrosion Properties of Materials

Course Description:

Content: Classification of corrosion. Chemical and electrochemical corrosion. Mechanisms of developing uniform, pitting and crevice corrosion. Contact, selective intergranular stress corrosion. Erosion, cavitation and other corrosion phenomena. Corrosive media -environment. Water and aqueous solutions, soil, marine and other atmospheres. Corrosion in the hot gases. The human body. Corrosion properties of major construction metals: mild steels, stainless steels, aluminum alloys, Al, Ti and Ti alloy. Copper and copper alloys. Monitoring of corrosion phenomena and corrosion testing.

Objectives: To know and understand the mechanisms of corrosion. Introduction of laboratory methods for corrosion testing of materials in order to determine their corrosion properties.

Lecturers: Prof. Vesna Alar, Asst. Prof. Vinko Šimunović

Literature:

1. E. Mattson: Basic Corrosion Technology for Scientists and Engineers, Chichester, 1989.
2. I. Esih, Z. Dugi: Tehnologija zaštite od korozije I – Teorija, ispitivanja korozije i ponašanje materijala, Školska knjiga Zagreb, 1990
3. Fontana and Greene: Corrosion Engineering, McGraw-Hill Book Company, Ohio
4. E.D.D. During: Corrosion Atlas, Elsevier, III izdanje, Nizozemska, 1997.

ISVU Number: 156149

ECTS Credits: 6

Semester: summer/winter

English Level: R1

Corrosion Protection

Course Description:

Content: Organic and unorganic coatings. Corrosion inhibitors. Electrochemical protection methods. Corrosion protection by proper construction designing.

Objectives: Introducion with methods for corrosion protection.

Lecturer: Prof. Vesna Alar

Literature:

1. D.A. Jones: Principles and prevention corrosion, Prentice Hall, New York, 1996.
2. E. Mattson: Basic Corrosion Technology for Scientists and Engineers, Chichester, 1989.
3. I. Esih, Z. Dugi: Tehnologija zaštite od korozije I – Teorija, ispitivanja korozije i ponašanje materijala, Školska knjiga Zagreb, 1990
4. Fontana and Greene: Corrosion Engineering, McGraw-Hill Book Company, Ohio
5. E.D.D. During: Corrosion Atlas, Elsevier, III izdanje, Nizozemska, 1997.

ISVU Number: 156150

ECTS Credits: 6

Semester: summer/winter

English Level: R1

Failure Analysis

Course Description:

Damages in the area of welded joints. Structural and plant accidents .Damage in operation due to pitting, intercrystalline and stress corrosion. Microbiological damage to materials. Damage caused by material wear. Erosion, abrasion and adhesion wear of materials. Material wear due to surface fatigue. To get acquainted with the problems of damage caused by operating conditions. Costs incurred due to accidents.

Lecturers: Prof. Vesna Alar, Asst. Prof. Ivan Stojanović

Literature:

1. R.H. Jones: Stress Corrosion Cracking,ASM International, Materials Park, Ohio, USA, 1999.
2. P.R. Roberge: Handbook of corrosion engineering, McGraw-Hill, New York, 2000
3. R.D.Port, H.M.Herro: The Nalco Guide to Boiler Failure Analysis, McGraw-Hill, New York, 1991

ISVU Number: 156151

ECTS Credits: 6

Semester: summer/winter

English Level: R1

High Efficiency Machining and Advanced Machine Tools

Course Description:

Introduce the new material removal processes that lead to greater efficiency and quality. Recognize relationships between material removal processes and Corporate Social Responsibility (CSR). Students will be able to judge and evaluate the basic modules of advanced machine tools, their characteristics and scope of application. They will know to categorize and choose the performance of numerically controlled machine tools and systems, such as machining centers, multitasking machine tools and flexible machining cells. Students will also be able to conclude the importance of cutting tool wear monitoring and diagnostics of advanced machine tool, with the purpose of his autonomy work.

Lecturers: Prof. Toma Udiljak, Prof. Damir Ciglar

Literature:

1. Science Direct Website: Annals of the CIRP, Elsevier J.P. Davim: Machining: Fundamentals and Recent Advances, Springer Verlag, 2008,
2. D. Dudzinski, A. Molinari, H. Schulz: Metal cutting and high speed machining, Kluwer Academic, 2002.
3. Cebalo, R., Ciglar, D. & Stoić, A., "Obradni sustavi: fleksibilni obradni sustavi", Zagreb, 2005 CIRP Proceedings

ISVU Number: 156117

ECTS Credits: 6

Semester: summer/winter

English Level: R2

Machining Systems Monitoring and Control

Course Description:

A student's introduction to various approaches in monitoring of machining systems with emphasize on: types of monitoring methods, characteristics of measuring equipment, signal filtering methods, types of features and algorithms for classification and estimation of monitored process/machine parameters. Upgrade of monitoring process with adaptive control models for constraining controlled process parameters or maintaining their optimal values. Analyzes of open architecture CNC systems and implementation of monitoring and control algorithms in the real-time environment based on Linux CNC platform.

Lecturer: Assoc. Prof. Danko Brezak

Literature:

1. S.-H. Suh, S.-K. Kang, D.-H. Chung, I. Stroud, Theory and Design of CNC Systems,ISBN 978-1-84800-335-4, Springer-Verlag London Limited, 2008.
2. Y. Altintas, Manufacturing Automation, ISBN 0-521-65029-1, Cambridge UniversityPress, 2000.
3. S. Soloman, Sensors and Control Systems in Manufacturing, ISBN:978-0-07-160573-1, The McGraw-Hill Companies, Inc., 2010.
4. L. Wang, R. X. Gao (Ed.), Condition Monitoring and Control for IntelligentManufacturing, ISBN 978-1-84628-268-3, Springer-Verlag London Limited, 2006.
5. O. D. I. Nwokah, Y. Hurmuzlu (Ed.), The Mechanical Systems Design Handbook:modeling, measurement, and control, ISBN 0-8493-8596-2, CRC Press LLC, 2002.
6. S. W. Smith, The Scientist and Engineer's Guide to Digital Signal Processing, ISBN0-9660176-7-6, California Technical Publishing, 1999.

ISVU Number: 156047

ECTS Credits: 6

Semester: summer/winter

English Level: R1

Micro and Nanotechnology

Course Description:

The scope of te course is to give a common understanding on the field of micro and nanotechnology and to introduce students into the basics of various micro and nanofabrication methods.

Lecturers: Assoc. Prof. Damir Godec, Prof. Mladen Šercer

Literature:

1. Globisch, S. et al.: Lehrbuch Mikrotechnologie, Carl Hanser Verlag, München, 2011.
2. KOÇ, M., ÖZEL, T.: Micro-Manufacturing, Design and Manufacturing of Micro-Products, John Wiley & Sons, Inc., 2011.
3. BINNS, C.: Introduction to Nanoscience and Nanotechology, John Wiley & Sons, Inc. Hoboken, New Jersey, 2010.

ISVU Number: 156110

ECTS Credits: 6

Semester: summer/winter

English Level: R2

Modern Additive Manufacturing of Products

Course Description:

Acquirement of basic knowledge from the field of Additive Manufacturing of products (Rapid Prototyping, Rapid Tooling, Rapid Manufacturing).

Lecturer: Assoc. Prof. Damir Godec

Literature:

1. Gibson, I., Rosen, D.W., Stucker, B.: Additve Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, Springer-Verlag GmbH, Berlin, 2010.
2. Gebhardt, A.: Rapid Prototyping, Carl Hanser Verlag, München, 2003.
3. Godec, D., Šercer, M.: Brza proizvodnja kalupa, Polimeri 28(2007)1, 32-39
4. Godec, D., Šercer, M., Pilipović, A.: Direct Rapid Tool Production, CIM 2009, 12th International Scientific Conference on Production Engineering, Proceedings, Hrvatska udruga proizvodnog strojarstva, Zagreb, Biograd, 17.-20.06.2009., 69-74
5. Godec, D.: Doktorski rad: Utjecaj hibridnog kalupa na svojstva injekcijski prešanog plastomernog otpreska, Fakultet strojarstva i brodogradnje, Sveučilište u Zagrebu, mentor: prof. dr.sc. Mladen Šercer (2005.)
6. Godec, D., Šercer, M.: Aditivna proizvodnja, Sveučilišni udžbenik, Sveučilište u Zagrebu, 2015.

ISVU Number: 156111

ECTS Credits: 6

Semester: summer/winter

English Level: R2

Modern Machine Tools and Their Modules

Course Description:

The aim of the course is to introduce students to the concept of a modular construction of modern numerically controlled machine tools and global trends of their development. Students will be able to judge and evaluate a variety of technical and technological characteristics of machine tools and their modules. The resulting knowledge will make them easier to caregorize, compare and choose the proper modern machine tool in its purchase, because the proper selection is essential for its further exploitation and utilization in a competitive and demanding market. The final goal of modern machine tools and their modules is to provide multiside and different machining processes in one set up of workpiece on a single machine tool, the autonomy of the machine tool and systems to enable its further reconfiguration and use of modern energy-saving modules. Students will also get to know the principles of measuring cutting force and CAD / CAM machining of parts, and will be able to conclude the importance of monitoring and diagnostics of modern machine tool.

Lecturer: Prof. Damir Ciglar

Literature:

1. Cebalo, R., Ciglar, D. & Stoić, A., "Obradni sustavi: fleksibilni obradni sustavi", (drugo izmijenjeno izdanje), Zagreb, 2005, ISBN 953-96501-6-X
2. Neugebauer, R.; Bouzakis K.D.; Denkena, B.; Klocke, F.; Sterzing, A.; Tekkaya, A.E. & Wertheim, R. (2011). Velocity effects in metal forming and machining processes, CIRP Annals – Manufacturing Technology 60 , p. 627–650, 2011
3. Abele, E.; Altintas, Y. & Brecher, C. (2010). Machine tool spindle units, CIRP Annals – Manufacturing Technology 59, str. 781–802, 2010

ISVU Number: 156154

ECTS Credits: 6

Semester: summer/winter

English Level: R2

Modern Trends in Material Removal Processes

Course Description:

To deepen the knowledge in theory of cutting, in particular in domain of machinability of materials and new methods for reaching machinability functions. Special attention will be given to complexity of research in machinability at non-conventional machining, micro machining and hybrid machining technologies as they became more numerous and more present in industry. Introduction of methods and tools enabling faster, but reliable, estimation of process parameters for reaching higher productivity and better product quality.

The goal is to prepare the students for scientific evaluation and application of contemporary machining technologies in order to improve the production processes.

Lecturers: Asst. Prof. Tomislav Staroveški

Literature:

1. D.A. Stephenson, J.S. Agapiou: Metal cutting theory and practice, CRC Taylor &Francis, 2006
2. W. Degner, H. Lutze, E. Smejkal,: Spanende Formung: Theorie, Berechnung,Richtwerte, Hanser Verlag, 2009.
3. Science Direct Website: Annals of the CIRP, Elsevier J.P. Davim: Machining:Fundamentals and Recent Advances, Springer Verlag, 2008.
4. Douglas C. Montgomery, DESIGN AND ANALYSIS CIRP Proceedings
5. B. Bhattacharyya, B. Doloi: Advanced, Hybrid, Micro Machining and Super Finishing Technology, Elsevier 2019

ISVU Number: 156114

ECTS Credits: 6

Semester: summer/winter

English Level: R2

Numerical Simulation of Metal Forming

Course Description:

Bring into the presence the methods, possibilities and advantages of using computer simulation in metal forming for the purpose of development the new manufacturing processes as well as improvement of existing ones. Comparison of various computer software for simulation of metal forming technologies. Realisation of own examples and solving own technological problems with the help of teacher in the aim of acquiring new knowledge and skills.

Lecturer: Asst. Prof. Zdenka Keran

Literature:

1. E. Hinton, D. Owen, Finite element method in plasticity, Oxford University Press, 1982.;
2. K. J. Bathe, Finite element procedures in engineering analysis, Prentice hall, 1982.;
3. K. Lange, Lehrbuch der Umformtehnik, Springer Verlag, 1992.;
4. G. Spur, T. Stoferle, Handbuch der Fertigungstechnik, Springer Verlag, New York 1984.

ISVU Number: 156093

ECTS Credits: 6

Semester: summer/winter

English Level: R2

Robotization and Automation of Welding

Course Description:

Robotized and automated welding processes. Establishment, mechanisms, drives, control, performance, programming and application of robots. Robots suitable for welding operations, accessories and formation of robotic cells. Programming and compatibility of robotic welding and cutting (GTAW, resistance welding, GMAW, laser). Economical analysis of implementing robots and machines into production. Safety measures and occupational safety in automated and robotized welding industry. Research on successful robot and machine implementation.

Lecturers: Assoc. Prof. Ivica Garašić, Prof. Zoran Kožuh

Literature:

1. Šurina T., Crneković M.: Industrijski roboti, Školska knjiga, Zagreb 1990.
2. Kralj S., Andrić Š.: Osnove zavarivačkih i srodnih postupaka, Sveučilište u Zagrebu, 1992.
3. N. Pires, A. Loureiro, G. Bölmsjo; "Welding Robots: Technology, System Issues and Application", Springer-Verlag London Limited 2006

ISVU Number: 156143

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Simulation of Casting Processes

Course Description:

Introduce students with options of the software for casting and solidification simulation. Teach students to use and work with QuikCAST software. Teach students how to read the results and their meaning.

Lecturer: Prof. Branko Bauer

Literature:

1. Casting, ASM Handbook, Vol. 15, ASM International, 2008.
2. R. Roller et al, Fachkunde für giessereitechnische Berufe, Europa-Lehrmitel Verlag, 2009.

ISVU Number: 156146

ECTS Credits: 6

Semester: summer/winter

English Level: R2

Special Casting Procedures

Note: course not offered in 2020-2021 academic year.

Course Description:

Introduction to the systematization of the casting technology according to the type of models (solid, fusible, evaporative, combustion). General information about special casting technologies (precise moulding casting, shell casting). Shell mould casting on moulding machines with vertical division of the mould. Vacuum casting of parts with small mass and dimensions . Centrifugal casting. Continuous casting. Acquisition of general and specific knowledge about the special casting procedures.

Literature:

1. Ivan Budić, Zoran Bonačić-Mandinić: Osnove tehnologije kalupljenja, Jednokratni kalupi II dio, Strojarsku fakultet, Slavonski Brod, 2004.
2. Ivan Budić: Posebni ljevački postupci, I dio, Strojarsku fakultet, Slavonski Brod, 2006.
3. Ivan Budić: Posebni ljevački postupci, II dio, Strojarsku fakultet, Slavonski Brod, 2009.

ISVU Number: 156198

ECTS Credits: 6

Semester: summer/winter

English Level: R0

Underwater Welding and Cutting

Course Description:

Physical – metallurgical properties of "wet" and "dry" underwater welding and cutting. Types of underwater welding with special overview according to the weld quality. Technology of welding and cutting, weldability of materials, underwater welding and cutting equipment, special properties of "wet" underwater welding filler materials, quality control, features of weld quality definitions. Occupational safety, ecological aspects of underwater welding and cutting.

Lecturers: Assoc. Prof. Ivica Garašić

Literature:

1. Underwater cutting and welding, US Navi Manual, 1989.
2. Specification for underwater welding, ANSI/AWS D3.6-93.
3. Hyperbaric wet welding pr EN ISO 15614-1
4. Document No. CSWIP-DIV-7-95 Part 1&2.
5. Ivica Garašić, "Osjetljivost čelik X70 na hladne pukotine pri mokrom podvodnom zavarivanju", Doktorska disertacija, FSB Zagreb, 2008.

ISVU Number: 156141

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Study module:

Aeronautical Engineering

List of fundamental elective courses of the doctoral study module:

1. Continuum Mechanics
2. Geometric Mechanics

List of elective courses of the doctoral study module:

1. Computational Aerodynamics
2. Fatigue and Fracture of Structures
3. Mechanical Integrity of Structures
4. Mechanics of Composite Structures
5. Modeling, Control and Design of Wind Turbines
6. Modeling, Simulation and Control of Flying Objects
7. Rotary Wing Aeroelasticity
8. Rotor Aerodynamics
9. Selected Topics of Strength of Aeronautical Structures

Continuum Mechanics

Course Description:

Introduction to Vectors and Tensors. Curvilinear Coordinates. Kinematics. Concept of Stress. Balance Principles. Objectivity. Linear elastic behaviour. Hyperelasticity. Fundamental of Continuum Plasticity. The Flow Theory of Plasticity. Flow Rule, Yield Criterion, Strain Hardening, Loading – Unloading Conditions. Finite Deformations in Plasticity. Viscoelasticity – linear and nonlinear models.

Lecturers: Prof. Emer. Ivo Alfirević, Assoc. Prof. Igor Karšaj

Literature:

1. Alfirević, I.: Uvod u tenzore i mehaniku kontinuuma, Golden Marketing, Zagreb, 2003.
2. Holzapfel, GA: Nonlinear Solid Mechanics – A Continuum Approach for Engineering, Wiley, 2000
3. Alfirevic, I: Tenzorski račun i tenzorska mehanika, Golden Marketing, Zagreb, 2006.

ISVU Number: 155493

ECTS Credits: 6

Semester: winter

English Level: R3

Geometric Mechanics

Course Description:

The goal of the course is to describe methods and algorithms of mathematical modelling of mechanical systems on differentiable manifolds – topological manifolds with a globally defined differential structure – with the aim of synthesis of computational models for dynamic analysis, control and guidance of mechanical systems. Once the chosen topics of differential geometry with the special focus on differentiable manifolds, vector fields on manifolds and Lie groups are delivered, the lectures will focus on the elements of Lagrangian and Hamiltonian mechanics on manifolds.

Special focus will be devoted to modelling of dynamics of discrete mechanical systems with holonomic and non-holonomic kinematical constraints, along with the methods of synthesis of computational models for numerical motion simulation and the basic principles of estimation of the control characteristics of the mechanical systems via geometric mathematical models and formulations.

Lecturer: Prof. Zdravko Terze

Literature:

1. Shutz, B.F.: Geometrical Methods of Mathematical Physics. Cambridge Univ. Press, Cambridge (1980)
2. Boothby, W.: An Introduction to Differentiable Manifolds and Riemannian Geometry. 2nd Edition, Academic Press (2003)
3. Darryl D. Holm: Geometric Mechanics. Part II: Rotating, Translating and Rolling. Imperial College Press, London (2008)
4. Bullo, F., Lewis, A.D.: Geometric Control of Mechanical Systems. Springer (2007)
5. Marsden, J. E., Ratiu, T.S.: Introduction to Mechanics and Symmetry. Springer (1999)
6. Iserles, Munthe–Kaas, Norsett and Zanna: Lie-group methods. Acta Numerica 9, 215–365 (2000)

ISVU Number: 156103

ECTS Credits: 6

Semester: winter

English Level: R3

Computational Aerodynamics

Course Description:

Students will be familiarised with numerical methods in computational aerodynamics, with applications to relevant aerospace geometries. Computational methods i aerodynamics are regularly applied in design and optimisation of aerospace components, typically by using commercial simulation packages. In order to use such engineering tools within their range of applicability and understand the accuracy and quality of simulation results, it is necessary to understand the basic physical model that is being simulated and understand the basics of numerical methods used for the solution. This lecture series shall present the physical basis of the turbulent compressible flow model and the Finite Volume method of discretisation used to obtain a numerical solution. The numerical model shall be tested by candidates on typical aerospace geometries. Candidates will be taught how to analyse the numerical results and evaluate the accuracy of the solution.

Lecturers: Prof. Hrvoje Jasak, Assoc. Prof. Željko Tuković

Literature:

1. R.S. Hirsch, Numerical Computation of Internal and External Flows, vol. I i II, John Wiley and Sons, New York, Brisbone, Toronto, Singapore, 1991.
2. D.A. Anderson, J.C. Tanchill, R.H. Pletcher, Computational flud mechanic and heat transfer, Hemisphere, New York, 1984.

ISVU Number: 156161

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Fatigue and Fracture of Structures

Course Description:

The main goals of this course are: Introduction to advanced experimental and numerical methods for fatigue and fracture analysis of structures. Analytical and numerical methods for determination of linear elastic fracture mechanic (LEFM) and elastic plastic fracture mechanics (EPFM) parameters. Fatigue crack growth simulation (for example by integrating the Paris equation) and estimation of fatigue crack propagation life of structures. Fracture analysis based on LEFM and EPFM parameters.

Specific goals are the knowledge transfer to students of new trends and possibilities of fatigue life analysis of structures based on application of fracture mechanics.

Lecturer: Prof. Željko Božić

Literature:

1. Schijve, J., Fatigue of Structures and Materials, Second Edition, Springer (2009).
2. Anderson, T.L., Fracture Mechanics Fundamentals and Applications, 3rd Edition,Taylor & Francis (2005).3.Broek, D., The practical use of fracture mechanics, Kluwer academic publishers(1989).
3. Kanninen, F., Popelar, C.H., Advanced fracture mechanics, Oxford University Press(1985).
4. Broek, D., Elementary Engineering Fracture Mechanics. 3rd Edition, NoordhoffInternational Publishing (2003).
5. Knot, J.F., Fundamentals of fracture mechanics, Butterworths, (1973).

ISVU Number: 156165

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Mechanical Integrity of Structures

Course Description:

The main goals of this course are: Introduction to advanced methods for structural integrity analysis. S-N curves, the Basquin equation, the Coffin-Manson equation. Damage accumulation models. Low Cycle Fatigue (LCF), High Cycle Fatigue (HCF) and Very High Cycle Fatigue(VHCF). Fatigue life estimation up to crack initiation.

Specific goals are the knowledge transfer to students of new trends and possibilities formechanical integrity analysis of structures.

Lecturer: Prof. Željko Božić

Literature:

1. Suresh, S., Fatigue of Materials, Cambridge University Press, 2nd Edition (2001).
2. Collings, J.A., Failure of Materials in Mechanical Design: Analysis, Prediction,Prevention. New York: Wiley & Sons, 2nd Edition (1993).
3. Schijve, J., Fatigue of Structures and Materials, Second Edition, Springer (2009).
4. Schmauder, S., Mishnaevsky, L., Micromechanics and Nanosimulation of Metals andComposites – Advanced Methods and Theoretical Concepts, Springer (2010)

ISVU Number: 156170

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Mechanics of Composite Structures

Course Description:

Objectives: Transferring to doctoral students knowledge related to advanced topics of mechanics of composite structures. The knowledge should be applicable at the continuation of research in the fields of analysis and synthesis of structural behaviour of aeronautical and similar thin walled composite structures, or related research topics. Furthermore, the objective is to motivate students to solve open problems in this area, by critical evaluation of the acquired knowledge.

Lecturing topics: Selected topics in continuum mechanics of non-isotropic materials. Material symmetry analysis – planes of elastic symmetry. Orthogonal transformations – conditions for material symmetry. Advanced methods in the analysis of composite shell structures. Methods for analysis of post-buckling behaviour. Composite beams with lumped masses. Rotating thin-walled anisotropic beams. Damage mechanics in composite structures – damage initiation and progression mechanisms.

Modelling of impact damage in composite structures. Selected topics in micromechanics of non-isotropic materials. Multiscale methods in mechanics of composites. Equation of State (EOS) and its application in mechanical analysis. Wave propagation problems in composite structures.

Lecturer: Prof. Ivica Smojver

Literature:

1. Liviu Librescu, Ohseop Song: Thin-Walled Composite Beams, Springer (2006)
2. Dewey H. Hodges: Nonlinear Composite Beam Theory, AIAA Nonlinear Composite Beam Theory (2006)
3. L. Kollar, G. Springer: Mechanics of Composite Structures, Cambridge University Press (2007)
4. Christos Kassapoglou, Design and Analysis of Composite Structures, AIAA Education Series (2010)
5. Serge Abrate: Impact on Composite Structures, Cambridge University Press (1998)

ISVU Number: 156167

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Modelling, Control and Design of Wind Turbines

Course Description:

The course offers a broad introduction to the engineering principles underlying the operation of wind turbines, as well as their design. The course is organized into five main modules, whose content is as follows:

Introduction: wind and wind energy, overview of wind energy systems and wind turbines; characteristics of a modern wind turbine; wind turbine components; electrical aspects.

Wind turbine aerodynamics: overview of rotor aerodynamics; one-dimensional momentum theory and Betz limit; wake swirl; airfoils; blade element momentum theory, dynamic inflow; unsteady corrections, blade tip and hub losses, dynamic stall, stall delay and three-dimensional effects; deterministic and stochastic wind models.

Dynamics and aeroservoelasticity: rigid and elastic flapping and lagging blade; the rotor as a filter, aerodynamic damping, flutter, limit cycle oscillations; loads; stability analysis; aeroservoelastic models of wind turbines; aeroservohydroelastic models for off-shore applications.

Wind turbine control: overview and architecture of wind turbine control systems; on-board sensors; supervisory control; regulation strategies; trimmers, load-reducing control, dampers; load and wind observers.

Wind turbine design: overview of design criteria and certification rules; aerodynamic design; structural design; design and choice of sub-systems and components.

Lecturers: Prof. Zdravko Terze, Prof. Carlo Bottasso

Literature:

1. T. Burton, N. Jenkins, D. Sharpe, E. Bossanyi, Wind Energy Handbook, Wiley, 2011.
2. J. F. Manwell, J.G. McGowan, A.L. Rogers, Wind Energy Explained, Theory, Design and Application, Wiley, 2012.

ISVU Number: 156060

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Modelling, Simulation and Control of Flying Objects

Course Description:

Basic objective of course is to describe methods and procedures creation numerical models of the motion and simulation of atmospheric flight of aircraft configurations as: projectile, cross wing, airplane and helicopter configurations, and for major application of flight simulation and flight control.

Within the course flight models with different applications will be described and analysed: for analysis of existing aircraft and design of new (its dynamic stability, handling quality and development of stability augmentation system); for analysis of operational application (flight simulation and simulation of the aircraft systems, simulation for pilot training device, analysis and synthesis of flight trajectory). Different flight models with different level of motion description, would be specified for different applications, though all models of different complexity assume knowledge of: aerodynamics, inertial model, propulsion and stability augmentation model. Basic flight model analyzed is nonlinear, six degrees of freedom model, 6DOF. Furthermore, specifics of flight simulation in real time would be presented. Modeling of different atmospheric conditions, non-deterministic values in the model and modeling of auxiliary systems would enable to simulate practical situations.

Lecturer: Prof. Milan Vrdoljak

Literature:

1. B. Etkin, L. D. Reid. Dynamics of Flight: Stability and Control, 3rd Ed., Wiley, New York, 1996.
2. Mark E. Dreier. Introduction to Helicopter and Tiltrotor Flight Simulation, AIAA, Washington, 2007.
3. S. Janković. Mehanika leta projektika, FSB, Zagreb, 1998.
4. B. L. Stevens, F. L. Lewis. Aircraft Control and Simulation, 2nd Edition, Wiley, New York, 2003.
5. P. H. Zipfel. Modeling and Simulation of Aerospace Vehicle Dynamics, Second Edition, AIAA, Washington, 2007.
6. G. D. Padfield. Helicopter Flight Dynamics: The Theory of Application of Flying Qualities and Simulation Modelling, 2nd Ed., Blackwell Publ., Oxford, 2007.

ISVU Number: 156185

ECTS Credits: 6

Semester: summer/winter

English Level: R2

Rotary Wing Aeroelasticity

Course Description:

The goal of the course is to provide an insight into problems associated with rotary wing aeroelasticity. The architecture of helicopter rotors is reviewed. The problems related to the description of the kinematics and dynamics of helicopter rotors, including structural dynamics, aerodynamics and control system dynamics are discussed. Advanced problems associated with vibration isolation, voluntary and involuntary pilot-vehicle interaction (PIO/PAO), rotor active control are presented and discussed.

The problem of rotor blade dynamics is formulated by separating the 3D nonlinear continuum dynamics problem in a section-wise 2D linear elasto-static problem for the structural characterization of the blade, and in a spanwise 1D nonlinear dynamics problem. Direct solution of initial-value problems as well as solution of stationary and periodic problems are presented. Aeroelastic stability of the rotor system is presented in terms of direct eigenanalysis of an equivalent linear time invariant (LTI) system obtained by perturbation about a steady solution, and of Floquet stability of a linear time periodic (LTP) system either formulated directly or obtained from identification of transient response. An original interpretation in terms of Lyapunov Characteristic Exponents directly computed from a Differential-Algebraic representation of the problem is proposed. An introduction to robust stability analysis is presented as a tool to determine the actual stability margins in the design parameter space.

Lecturers: Prof. Zdravko Terze, Prof. Pierangelo Masarati

Literature:

1. Peretz P. Friedmann, Rotary Wing Aeroelasticity, In: Encyclopedia of Aerospace Engineering, Wiley, 2010.
2. Richard L. Bielawa, Rotary Wing Structural Dynamics and Aeroelasticity, AIAA, 2006.
3. Terze, Z.: Eiber, A., Introduction to Dynamics of Multibody Systems, FSB Zagreb, e-book, 2002.
4. Eich-Soellner, E.; Fuehrer, C.: Numerical Methods in Multibody Dynamics, B. G. Teub. Stuttgart, 1998.

ISVU Number: 156124

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Rotor Aerodynamics

Course Description:

Basic objective of the course is to present current methods of analysis of rotor aerodynamics, rotating lifting surfaces, with application to airplane propellers, helicopter rotors and wind turbines rotors.

Physical phenomena for mentioned aerodynamic objects are of the same nature, therefore it is justified to apply same models for analysis of its aerodynamic characteristics. It is proven that the wake has significant influence on the aerodynamic loads of the rotor itself so attention is given to the wake modeling. Emphasis is on the models based on the vortex theory and free-wake method. Non-symmetric flow of the rotor and accompanying load as practical situation is analysed. Within the course a static aerodynamic characteristics of the airfoil including high angle of attack and low Reynolds number, a short note on basic models of elastic blades and key aerodynamic effects for rotor design. Furthermore, unsteady aerodynamics effects caused by periodic blade motions, particularly for helicopter rotors, are analysed and its influence on loading and rotor performance are estimated, also associated phenomena of dynamic stall is presented.

Lecturers: Prof. Milan Vrdoljak

Literature:

1. J. G. Leishman. Principles of Helicopter Aerodynamics, 2nd Ed., Cambridge University Press, New York, 2006.
2. R. W. Prouty. Helicopter Performance, Stability and Control, Kreiger Publ., Malabar, 2003.
3. M.O.L. Hansen. Aerodynamics of Wind Turbines, 2nd Ed., Earthscan, London, 2008.
4. J. Katz, A. Plotkin. Low Speed Aerodynamics, 2nd Ed., Cambridge University Press, New York, 2001.
5. B. W. McCormick. Aerodynamics, Aeronautics and Flight Mechanics, 2nd Ed., Wiley, New York, 1995.
6. W. F. Phillips. Mechanics of Flight, 2nd Ed., Wiley, New York, 2010.

ISVU Number: 156188

ECTS Credits: 6

Semester: summer/winter

English Level: R2

Selected Topics of Strength of Aeronautical Structures

Course Description:

Objectives: Transferring to doctoral students knowledge related to advanced topics of mechanics of solids. The knowledge should be applicable at the continuation of research in the fields of analysis and synthesis aeronautical structures and similar research topics. Furthermore, the objective is to motivate students to solve open problems in this field, by critical evaluation of the acquired knowledge. Lecturing should also enable discussion on the prospective topics proposed by students. These topics, should be associated with lectures, and already defined as the fields of research within their Dissertations.

Lecturing topics: Nonlinear bending analysis of plates and shells – large displacements and rotations. Nonlinear geometric effects in buckling of plates. Post-critical panel behaviour. Geometrically nonlinear cylindrical shells. Buckling in shells. Buckling of stiffened panels. Post-critical behaviour. Basic equations in modelling crash-worthiness of aeronautical structures and impact dynamics. Structural behaviour at high strain rates and strengthening effects. Nonlinear theory in modelling thermal stresses at large temperature ranges and high thermal gradients.

Lecturer: Prof. Ivica Smojver

Literature:

1. Scott T. Dennis, Anthony N. Palazotto: Nonlinear Analysis of Shell Structures, AIAA Education Series (1992)
2. Jonas A. Zukas, Theodore Nicholas, Hallock F. Swift: Impact Dynamics, Krieger Pub Co (1992)
3. Stefan Hiermaier: Structures Under Crash and Impact – Continuum Mechanics, Discretization and Experimental Characterization, Springer (2008)
4. Earl A. Thornton, Thermal Structures for Aerospace Applications, AIAA Education Series (1996)
5. G.Z.Voyiadjis, P.I. Katan: Advances in Damage Mechanics: Metals and Metal Matrix Composites, Elsevier (1999)

ISVU Number: 156168

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Study module:

Computational Mechanics

List of fundamental elective courses of the doctoral study module:

1. Continuum Mechanics
2. Numerical Linear Algebra

List of elective courses of the doctoral study module:

1. Advanced Methods of Numerical Analysis of Structures
2. Biological Flows
3. Computational Biomechanics
4. Environmental Aerodynamics
5. Fracture Mechanics, Damage and Fatigue
6. Modeling from Macro- to Nano-Scale
7. Numerical Methods of Nonlinear Analysis of Structures
8. Structural Computational Dynamics
9. Transport Phenomena

Continuum Mechanics

Course Description:

Introduction to Vectors and Tensors. Curvilinear Coordinates. Kinematics. Concept of Stress. Balance Principles. Objectivity. Linear elastic behaviour. Hyperelasticity. Fundamental of Continuum Plasticity. The Flow Theory of Plasticity. Flow Rule, Yield Criterion, Strain Hardening, Loading – Unloading Conditions. Finite Deformations in Plasticity. Viscoelasticity – linear and nonlinear models.

Lecturers: Prof. Emer. Ivo Alfirević, Assoc. Prof. Igor Karšaj

Literature:

1. Alfirević, I.: Uvod u tenzore i mehaniku kontinuuma, Golden Marketing, Zagreb, 2003.
2. Holzapfel, GA: Nonlinear Solid Mechanics – A Continuum Approach for Engineering, Wiley, 2000
3. Alfirevic, I: Tenzorski račun i tenzorska mehanika, Golden Marketing, Zagreb, 2006.

ISVU Number: 155493

ECTS Credits: 6

Semester: winter

English Level: R3

Numerical Linear Algebra

Course Description:

To understand concepts of the numerical linear algebra and scientific computing with emphasys how to choose a method for solution of the problem and the possible numerical errors in obtained results. Learn how to use the numerical libraries for solution of subproblems.

Lecturer: Prof. Sanja Singer

Literature:

1. James W. Demmel, Applied Numerical Linear Algebra, SIAM, 1997.
2. Lloyd N. Trefethen and David Bau, III, Numerical Linear Algebra, SIAM 1997.

ISVU Number: 155491

ECTS Credits: 6

Semester: winter

English Level: R2

Advanced Methods of Numerical Analysis of Structures

Course Description:

Advanced finite element formulations. Mixed finite element formulation. Extended finite element formulation (XFEM). Boundary element formulation. Fundamental solution of differential equation. Finite volume formulations. Meshless methods. Galerkin formulation. Local Petrov-Galerkin (MLPG) formulation. Collocation methods. Interpolation functions in meshless formulations. Isogeometric formulations. B-sline and NURBS interpolations. Solving boundary value problems by means of isogeometric methods. Convergence and error assesment in numerical methods. Verification and validation of the solutions.

Lecturers: Assoc. Prof. Tomislav Jarak, Prof. Jurica Sorić

Literature:

1. Zienkiewicz,O.C., Taylor, R.L., Zhu, J.Z.: The Finite Element Method, its Basis and Fundamentals, Elsevier, Amsterdam, 2006.
2. Mohammadi , S.: Extended finite element method for fracture analysis of structures Blackwell Publishing, Oxford 2008.
3. Schäfer, M., Computational Engineering, Introduction to Numerical Methods, Springer Verlag, Berlin 2006.
4. Cotrell, J.A., Hughes, T.J.R, Bazilevs, Y.: Isogeometric Analysis: Toward Integration of CAD and FEA, Wiley, Chichester 2009.

ISVU Number: 156195

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Biological Flows

Course Description:

Basic laws of Fluid Dynamics to blood flow in circulatory system. Numerical methods for one-dimensional pulsatile flow in viscoelastic pipes. Learning outcomes: To formulate one-dimensional (1D) mathematical model of blood flow in the arterial tree, including the lumped models for peripheral circulation. To solve linear 1D model in frequency domain.Aapply the Method of characteristics to 1D pulsatile flow in viscoelastic tubes. Identificate parameters of lumped model from the measured aortic root flow and pressure.Rrecommend the use of hybrid (3D-1D-0D) hemodynamic models.

Lecturers: Prof. Zdravko Virag

Literature:

1. C.G. Caro, T.J. Pedley, R.C. Schroter,W.A. Seed: The Mechanics of the Circulation, Cambridge University Press, (2012).
2. J. T. Ottesen, M. S. Olufsen, J. K. Larsen: Applied Mathematical Models in Human Physiology, SIAM (2004).

ISVU Number: 156215

ECTS Credits: 6

Semester: summer/winter

English Level: R2

Computational Biomechanics

Course Description:

Overview of tissue structures. Bone tissue – the structure, the experimental findings, a review of numerical models. Soft tissue. Numerical modeling of the basic structure (elastin, collagen, smooth muscle cells). Intervertebral disc – the structure, the experimental findings, a review of numerical models. Cartilage – the structure, the experimental findings, a review of numerical models. Tendon and ligaments – the structure, the experimental findings, a review of numerical models. The cardiovascular system – the structure, the experimental findings, a review of numerical models. Heart.

Lecturer: Assoc. Prof. Igor Karšaj

Literature:

1. Cowin, SC, Doty, BD: Tissue Mechanics, Springer, 2007
2. Humphrey JD, Cardiovascular Solid Mechanics – cells, Tissues, and Organs, Springer, 2001
3. Truskey GA, Yuan, F, Katz, DF: Transport Phenomena in Biological Systems, Pearson, Prentice Hall, 2009
4. Fung, Y. C. Biomechanics: Mechanical Properties of Living Tissues. New York, NY: Springer-Verlag, 1993.

ISVU Number: 156119

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Environmental Aerodynamics

Course Description:

Following topics will be presented in lectures: Basic fluid mechanics, turbulence, atmospheric boundary layer flow, building and vehicle aerodynamics, air pollutant dispersion in lower atmosphere, wind energy, experimental and computational research tools. Students will be required to carry out research on one of the topics listed above and write a paper.

Lecturer: Prof. Hrvoje Kozmar

Literature:

1. Sockel Helmut: Aerodynamik der Bauwerke, Friedr. Vieweg & Sohn, 1984.
2. Simiu Emil, Scanlan Robert H.: Wind Effects on Structures, John Wiley & Sons, 1986.
3. Wolf-Heinrich Hucho: Aerodynamik der stumpfen Körper, Friedr. Vieweg & Sohn, 2002.
4. John D. Holmes: Wind loading of structures, Spon Press, 2001.

ISVU Number: 156125

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Fracture Mechanics, Damage and Fatigue

Course Description:

Basic principles of damage mechanics. Thermodynamics of damage. Scalar and tensorial interpretation of damage. Constitutive equations of metals, polymers, composites and biological tissues. Numerical algorithms for integration of constitutive equations. Crack initiation criterions. Numerical analysis of crack initiation. Basic principles of linear and elastic-plastic fracture mechanics as well as dynamic and time dependent fracture. Experimental methods in fracture mechanics. Finite element method in linear and nonlinear fracture mechanics. Determination of fracture mechanics parameters. Basic principles of fatigue. Numerical analysis of crack propagation. Application of damage and fracture mechanics to design and integrity assessment of structures.

Lecturer: Prof. Zdenko Tonković

Literature:

1. Lemaitre, J., A Course on Damage Mechanics, Second Edition, Springer, Berlin 1996.
2. Zhang, W., Cai, Y., Continuum Damage Mechanics and Numerical Applications, Springer, Heidelberg 2010.
3. Anderson, T.L., Fracture Mechanics: Fundamentals & Applications, CRC Press, Boca Raton 1994.

ISVU Number: 156211

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Modelling from Macro- to NanoScale

Course Description:

Basics of molecular dynamics. Capabilities and limitations of atomistic simulations. Multiscale modeling. Bridging from atomistic to continuum model. Hierarchical approaches. Concurrent approaches. Cauchy-Born rule. Numerical algorithms for solving macro-nano scale transition problems. Micromechanical modeling of heterogeneous materials. Representative volume element (RVE). Homogenization principles. First-order computational homogenization. RVE discretization using the finite element method and meshless method. RVE boundary value problem. Determination of macroscopic stress and tangent operator. Second-order computational homogenization. Numerical algorithms for solving macro-micro scale transition problems. Solving real engineering problems.

Lecturers: Prof. Zdenko Tonković, Prof. Jurica Sorić

Literature:

1. Harold S. Park Wing Kam Liu, Eduard G. Karpov: Nano Mechanics and Materials Theory, Multiscale Methods and Applications, John Wiley & Sons, Ltd, 2006.
2. Pfeiffer, F., Wriggers, P., Lecture Notes in Applied and Computational Mechanics, Vol. 20, Corrected Second Printing, Springer Verlag, 2008.
3. Galvanetto, U., Aliabadi, M.H.F., Multiscale Modeling in Solid Mechanics, Computational Approaches, Vol. 3, Imperial College Press, 2010.

ISVU Number: 156200

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Numerical Methods of Nonlinear Analysis of Structures

Course Description:

Basic relations of geometrical nonlinear theory. Basic relations of the theory of plasticity under the assumption of small and finite strains. Finite element formulations for solving geometrical and material nonlinearities. Numerical algorithms for solving global nonlinear problems. Constitutive equations for solving elastoplasticity problems. Von Mises flow rule, formulation of isotropic and kinematic hardening. Nonisothermal constitutive models. Formulation of cyclic plasticity. Methods for integration of constitutive equations. Solving the problems of anisotropic elastoplasticity. Applications of the algorithms derived for solving real problems.

Lecturers: Prof. Jurica Sorić, Prof. Zdenko Tonković

Literature:

1. Kojić, M., Bathe, K-J., Inelastic Analysis of Solids and Structures, Springer, Berlin 2005.
2. Dunne, F., Petrinic, N., Introduction to Computational Plasticity, Oxford University Press, Oxford 2007
3. Ibrahimbegović, A., Nonlinear Solid Mechanics, Theoretical Formulations and Finite Element Solution Methods, Springer, Dordrecht 2009.

ISVU Number: 156192

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Structural Computational Dynamics

Course Description:

Understaning of numerical methods for modelling, analysis, design and modification of dynamic behaviour of machines: dynamics of rigid machines, foundation and vibration isolation, torsional vibration, bending vibration, optimisation of machines with regard to vibrations.

Lecturer: Asst. Prof. Marko Jokić

Literature:

1. John H. Argyris, Hans-Peter Mlejnek: Dynamics of structures, North-Holland, 1991.
2. Ted Belytschko, Thomas J. R. Hughes: Computational Methods for Transient analysis, North-Holland, 1983.
3. Zu-Qing Qu: Model Order Reduction Techniques: with Applications in Finite Element Analysis, Springer, 2004.
4. Angeles, J: Dynamic Response of Linear Mechanical Systems. Modeling, Analysis and Simulation, Springer, New York, 2011.
5. H. Dresig, F. Holzweißig: Dynamics of Machinery, Springer-Verlag Berlin Heidelberg 2010.

ISVU Number: 156138

ECTS Credits: 6

Semester: summer/winter

English Level: R1

Transport Phenomena

Course Description:

Basic principles of the following viscous fluid flow classes: non – Newtonian fluid flow, multi component homogenous fluid flow, fluid flow with chemical reaction, multi-phase fluid flow. Learning outcomes: Set up and define the flow model (with or without heat transfer, with or without chemical reaction, with or without phase change, with or without discrete particles). Define the domain, set the boundary conditions and with the help of a computer package to solve the flow. Implement the heat developed by chemical reaction in the flow model. Implementation of new chemical species formed by chemical reaction in the flow model.

Lecturers: Prof. Ivo Džijan, Prof. Mario Šavar

Literature:

1. Bird, R.B.; Stewart, W.E.; Lightfoot, E.N.: Tranport phenomena, John Wiley & Sons, NY,1960.
2. Sherwood, T.K.; Pigford, R.L.; Wilke, C.R.: Mass Transfer, John Wiley & Sons, NY, 1973.
3. Streeter, V. L. : Handbook of fluid dynamics, McGraw-Hill, N.Y., 1961

ISVU Number: 156199

ECTS Credits: 6

Semester: summer/winter

English Level: R1

Study module:

Industrial Engineering and Management

List of fundamental elective courses of the doctoral study module:

1. Numerical Linear Algebra
2. Operations and Project Management

List of elective courses of the doctoral study module:

1. Design and Analysis of Experiments
2. Engineering Ethics and Social Responsibility
3. Intelligent Information Systems
4. Intelligent Process Planning
5. Maintenance Management
6. Operations Research in Logistics
7. Quality Management
8. Sustainable Production

Numerical Linear Algebra

Course Description:

To understand concepts of the numerical linear algebra and scientific computing with emphasys how to choose a method for solution of the problem and the possible numerical errors in obtained results. Learn how to use the numerical libraries for solution of subproblems.

Lecturer: Prof. Sanja Singer

Literature:

1. James W. Demmel, Applied Numerical Linear Algebra, SIAM, 1997.
2. Lloyd N. Trefethen and David Bau, III, Numerical Linear Algebra, SIAM 1997.

ISVU Number: 155491

ECTS Credits: 6

Semester: winter

English Level: R2

Operations and Project Management

Course Description:

The Operations and Project Management provides students with knowledge about models, methods and techniques that are used in Operations Management as one of the most important function in manufacturing and services organizations. The emphasis is on planning, organization and control of production and service processes with optimal use of company resources (land, capital, labour and information). Through the use of quantitative techniques students will learn how to to lead and improve processes in manufacturing, service, quality, and supply chain.

The goal is for students to specialize in certain areas of production management, which are important for their professional activity in the workplace. Topics of seminar will be associated with the selected area of specialization and will be selected on the research problem to apply the knowledge acquired through the lecture. In that way, students will learn to review the scientific literature and prepare scientific articles.

Lecturers: Prof. Nedeljko Štefanić, Asst. Prof. Miro Hegedić

Literature:

1. Heizer J., Render B. Munson C.: Operations Management, Pearson, London, 2017.
2. Chase R.B., Jacobs F.R., Aquilano N.J.: Operations Management for Competitive Advantage, Mc Graw Hill, eleventh edition, Boston, 2006.
3. Stevenson J.W.: Operations Management, Mc Graw Hill, tenth edition, New York, 2009.
4. Schroeder R.G.: Upravljanje proizvodnjom-odlučivanje u funkciji proizvodnje, MATE, Zagreb, 1999.
5. Schermerhorn J.R.: Management, John Wiley &Sons Inc., 8th edition, 2005.

ISVU Number: 156218

ECTS Credits: 6

Semester: winter

English Level: R3

Design and Analysis of Experiments

Course Description:

Introduce students with basic principles of experiment planning and analyzing, especially sampling theory which are crucial in the process of making inferences about an observed phenomenon or process. Point out the meaning and show examples of implementation of design of experiments.

Lecturer: Asst. Prof. Hrvoje Cajner

Literature:

1. Montgomery D. C., "Design and Analysis of Experiments", Fifth Edition, John Wiley & Sons, 1997.
2. Myers, Raymond H., Montgomery, Douglas C., "Response Surface Methodology, Process and Product Optimization Using Designed Experiments", John Wiley & Sons, 1995.
3. Douglas C. Montgomery, Statistics for the engineering and computer sciences, John wiley&sons, New York, 2003.
4. Hinkelman, K., Kempthorne, O., "Design and Analysis of Experiments", Vol. 1, Second Edition, Wiley&Sons, New Jersey, 2008.

ISVU Number: 156174

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Engineering Ethics and Social Responsibility

Course Description:

The main goals of the elective are focused to introduction of students to scientific-theoretical approaches in engineering ethics and social responsibility. Selected topics refer to: ethical aspects in scientific work such as plagiarism, counterfeiting, unethical experimentation and fabrication; selected topics of engineering ethics in industrial perspective such as public safety protection, technical competence and timely reporting on problems; intra-organizational aspects of social responsibility with regard to hierarchical distribution of social power; extra-organizational aspects of social responsibility mainly with regard to introduction of broader social community into social construction and resolution of technical issues.

Lecturer: Assoc. Prof. Nikša Dubreta

Literature:

1. Baillie, C., Pawley, A. L., Riley, D. (2012). Engineering and Social Justice: In theUniversity and Beyond. Purdue University Press.
2. Beder, S. (1998) The New Engineer: Management and Professional Responsibility in a Changing World. Harry Ranson Humanities Research Center.
3. Harris C. E., Pritchard, M. S., Rabins, M. J. (2008). Engineering Ethics: Concepts and Cases. Wadsworth Publishing

ISVU Number: 156133

ECTS Credits: 6

Semester: summer/winter

English Level: R2

Intelligent Information Systems

Course Description:

The aim of the course "Intelligent Information Systems" is to introduce students to the possibilities of applying advanced methods of artificial (AI) and business (BI) intelligence to support the classic business information systems in business analysis and decision making. The course thematic covers the following topics: 1. Database modeling (conceptual, logical, physical integrity and security), 2. Data management (management of information contents, information retrieval, modeling poorly structured data), 3. Introduction to methods of artificial intelligence (expert systems, artificial neural networks, fuzzy logic, evolutionary algorithms), 4. Business intelligence in business analysis and decision making (dimensional data analysis, OLAP analytical tools for data processing, ETL tools for knowledge discovery from databases). Once acquired theoretical knowledge, students will be able to independently modeled intelligent business information system that based on hidden knowledge in business data, provide better business management decisions and thus make the company more competitive.

Lecturer: Prof. Dragutin Lisjak

Literature:

1. R.Elmasri, S. Navathe: Fundamentals of Database Systems, 6th Edition, Addison Wesley, Reading MA, 2010.
2. J. Laudon: Essentials of Managament Information Systems, 8th Edition, Prentice Hall Inc., 2008.
3. M. Negnevitsky: Artificial Intelligence A Guide to Intelligent Systems, 2th Edition, Addison Wesley, 2009.
4. C. Vercellis: Business Intelligence : Data Mining and Optimization for Decision Making, John Wiley & Sons Ltd., 2009.

ISVU Number: 156051

ECTS Credits: 6

Semester: summer/winter

English Level: R1

Intelligent Process Planning

Course Description:

Fundamentals of process planning. Fundamentals of artificial intelligence. Expert systems, fuzzy logic, neural networks, genetic algorithms. Decision support. Intelligent manufacturing. Overview of AI techniques in process planning. The concept of optimum in manufacturing. Finding the optimal primary process, types and sequences of processes, machines, tools. Cost-effectiveness of material and quantitative methods for selection of materials. Group technology. Types of CAPP. Examples of the application of AI methods in processes. Developed AI systems in process planning. Benchmarking. Link between production strategies and equipment automation level. Basics of Expert Choice, LPA, MathLab software. Seminar work: production time optimization, selection of material, sequence of operations, machine tool, tools, variants of product manufacturing/new production. Intelligent process planning as part of virtual manufacturing.

Lecturer: Asst. Prof. Tihomir Opetuk

Literature:

1. A. Kusiak, Intelligent Manufacturing Systems, Prentice Hall, USA New Jersey, 1990.
2. P. Gu, Intelligent Manufacturing Planning, Chapman & Hall, London, 1995.
3. G. Halevi, Process and Operation Planning, Revised Edition of The Principles of Process Planning: Logical Approach, Kluwer Academic Publishers, London, 2003.
4. E. Cox, Fuzzy Systems Handbook, AP Professional, Boston, 1994.
5. J.A. Freeman, Neural Networks, Addison-Wesley Publishing Companxy1991.
6. F.M. McNeill, E. Thro, Fuzzy Logic, AP Professional, Boston, 1994.
7. Tien-Chien Chang, Expert Process Planning for Manufacturing, Addison-Wesley Publishing Company, New York, 1990.
8. Z. Michalewicz, Genetic Algorithms + Data Structures=Evolution Programs, Springer-Verlag, Berlin, 1994.
9. M.G.Runwei Cheng, Genetic Algorithms and Engineering Design, John Wiley & Sons, New York, 1997.
10. M.F. Ashby, Materials Selection in Mechanical Design, Pergamon Press, Oxford, 1992.
11. W. Eversheim, Innovation Management for Technical Products, Springer, Aachen, 2009.

ISVU Number: 156055

ECTS Credits: 6

Semester: summer/winter

English Level: R1

Maintenance Management

Note: course not offered in 2020-2021 academic year.

Course Description:

The aim of the course "to managers of maintenance" is to introduce students to modern organizational concepts (strategies) technical maintenance management system, and target to increase efficiency and reduce maintenance costs. The course discusses the following topics: 1. Maintenance organization (objectives, responsibilities, organizational models), 2. Productivity Maintenance (performance indicators-KPI according to EFNMS), 3. Methods and tools maintenance (introduction to the theory of probability distribution function, MTBF calculation, the FMCA / RCA / CED analysis), 4. Control of maintenance system (control work orders / budget / cost / quality), 5. Planning and scheduling (planning / forecasting capacity, Box-Jenkins time series models, the spare parts management), 5. Maintenance strategies (RCM / TPM, maintenance based on failure prediction, E-maintenance), 6. Maintenance and safety (accident prevention, human error in maintenance), 7. Improving the quality of maintenance (CMMS systems, benchmarking, Lean Maintenance, World Class Maintenance). Once acquired theoretical and practical knowledge of the course, students will be able to independently implementation of modern concepts and strategies that are aimed to the world class maintenance level.

Lecturer: Prof. Dragutin Lisjak

Literature:

1. B. Chanter, P. Swallow: Building Maintenance Managament, 2th Edition, Blackwell Publishing Ltd, Oxford, UK, 2007.
2. M. Ben-Daya, S.O. Duffuaa, A. Raouf, J.Knezevic, D. Ait-Kadi: Handbook of Maintenance Management and Engineering, Springer-Verlag, London, 2009.
3. D. Palmer: Maintenance Planning and Scheduling Handbook, 2th Edition, McGraw-Hill, 2006.
4. A. Kelly: Maintenance Systems and Documentation, 1st Edition, Elsevier Ltd., 2006.
5. A. Kelly: Strategic Maintenance Planning, 1st Edition, Elsevier Ltd., 2006.
6. R. Smith, B. Hawkins: Lean Maintenance: reduce costs, improve quality, and increase market share, Elsevier Butterworth–Heinemann, 2004.

ISVU Number: 156052

ECTS Credits: 6

Semester: summer/winter

English Level: R1

Operations Research in Logistics

Course Description:

Introduce students with quantitative tools and techniques from Operations Research (OR) in application to solving logistics and supply chain management (SCM) problems. ″Operations Research in Logistics″ course focuses on selected areas in logistics and SCM (transportation management and route planning, strategic procurement, inventory management, warehouse design and operations, location theory and distribution network planning and design, green supply chain management, reverse logistics) that require knowledge and skills where practitioners and researchers apply academically developed theories and models from operations research. Aims of this course are to initiate PhD students to the modern research topics in logistics and SCM, to enable application of existing models to complex real-world logistics and supply chain problems, as well as to create basis for research and development of new models. Sub-specialisation in particular area of logistics and SCM is possible and encouraged with seminar based on scientific literature review of specific research problem, leading toward preparation of research article and/or part of PhD thesis.

Lecturer: Prof. Goran Đukić

Literature:

1. Gianpaolo Ghiani, Gilbert Laporte, Roberto Musmanno: Introduction to logistics systems planning and control, ISBN 9780470849163, 2004 John Wiley & Sons, Ltd
2. Simchi-Levi, Chen, Bramel: The Logic of Logistics:Theory, Algorithms, and Applications for Logistics and Supply Chain Management, ISBN 978-0-387-22619-4, Springer 2005
3. Bartholdi, Hackman: Warehouse & Distribution Science, release 0.95 pdf book, The Supply Chain and Logistics Institute, Atlanta USA, 2012
4. Dolgui, Proth: Supply Chain Engineering: Useful Methods and Techniques, ISBN 978-1-84996-016-8, Springer 2010
5. Langevin, Riopel (editori): Logistcs Systems: Design and Optimization, ISBN 978-0387-24971-1, Springer 2005
6. Fleischmann: Quantitative Models for Reverse Logistics, ISBN 978-3-540-41711-8, Springer 2001

ISVU Number: 156088

ECTS Credits: 6

Semester: summer/winter

English Level: R1

Quality Management

Course Description:

Definition of quality. Understanding quality managenment. Traditional and modern approach. Gurus of quality. The need for standardisation and quality management systems. Customer and quality. QFD. FMEA. The cost of quality. Taguchi philosophy. Principles of management for quality. Process planning. SPC. Process capability. Continuous improvement of process quality. Six sigma methodology. Changes and changes in management. Excellence criteria. Global quality awards.

Lecturer: Prof. Biserka Runje

Literature:

1. Watson, G. H. The Legacy of Ishikawa, Quality Progress, April 2004, pp. 54 – 57.
2. QP Staff. Guru Guide, Six thought leaders who changed the quality world forever, Qality Progress, November 2010, pp.14 – 21.
3. Phillips-Donaldson, D. 100 Years of Juran, Quality Progress, May 2004, pp.25 – 39.
4. Deming, W. E. The New Economics for Industry, Government, Education (2nd ed.). MIT Press, 2000.
5. Feigenbaum, A.V. Total Quality Control, McGraw-Hill, 1991.
6. Bass, I., Lawton, B. Lean Six Sigma, McGraw-Hill, 2008.

ISVU Number: 156221

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Sustainable Production

Course Description:

Understanding the strength of connection between economic, cultural and historical development of society, sustainable development and production. Students will learn the following: Understanding the link between global/local strategy of sustainable production, environmental approach to production, and socially responsible behavior with the operational tools for global/local implementation of harmful substances emissions and energy efficiency assessment of products/production. Ecological approach to production includes: fees for the environment, environmental permits, compliance with the best available techniques, and certification (ISO 14001). Consideration of the broader context of LCA from the aspects of sustainable development, ecological approach to production, ecological footprint, and mutual relations with Eco Design, Life Cycle Analysis, Life Cycle Initiative, Life Cycle Management and Total Cost Estimation. Adoption of the procedures for conducting the LCA with a critical analysis of the results. Getting familiar with the EU environmental legislation, (IPPC Directive), environmental legislation in the Republic of Croatia (laws, regulations, etc.), and actions in this area in the Croatian state bodies, non-profit organizations and companies.

Lecturer: Asst. Prof. Tihomir Opetuk

Literature:

1. Cheremeisinoff N. ''Handbook of Cleaner Production'' Elsevier, 2009.
2. Ralph Horne: Life Cycle Assessment: Principles, Practice and Prospects (Paperback), CSIRO PUBLISHING, 2009.
3. Umberto softver podloge.
4. Podloge za SimaPRO, PhD.
5. Jurgensen A. Sustainable Production: Annotatated Bibliography, The Scarecrow Press, Inc.; Annotated edition, 2001.
6. Weizsäcker, E. U., Lovins, A. B. and Lovins, L. H.: Factor Four: Doubling Wealth, Halving Resource Use Earthscan Publications, Ltd, London, 1998.
7. Horn R. "Life Cylce Asssessment: Principles, Practices and Prospectes" Springer-Verlag 2009.
8. Wenzel H., Hauschild, M., Alting, L. ''Environmental Assessment of Products'', Volume 1/2, Chapman & Hall, 2000, 1997.
9. UNEP, Why Take A Life Cycle Approach?, 2004.
10. Life Cycle Assessment, An Operational Guide to the ISO standards.
11. Lebel, L., Lorek, S. and Rajesh Daniel : Sustainable Production Consumption Systems: Knowledge, Engagement and Practice, Springer, 206.

ISVU Number: 156216

ECTS Credits: 6

Semester: summer/winter

English Level: R1

Study module:

Materials Engineering

List of fundamental elective courses of the doctoral study module:

1. Heat Treatment and Surface Engineering
2. Materials Science and Engineering
3. Modeling in Materials Research

List of elective courses of the doctoral study module:

1. Advanced Metal Construction Materials
2. Advanced Tool Materials
3. Cellular Materials
4. Composite Materials
5. Engineering Ceramics
6. Functional Materials
7. Materials and Environment
8. Materials Selection and Product Development
9. Mechanical Properties of Materials
10. Methods of Materials Characterization
11. Nanostructured Materials
12. Polymer Materials
13. Thermodynamic and Structure of Materials
14. Tribology

Heat Treatment and Surface Engineering

Course Description:

The objectives and content of the course are focused on the following topics:

(1) To provide the students with the necessary fundamentals for understanding the material properties given by the available heat treatment processes as well as with surface modification and coating processes.

(2) To gain knowledge about the materials used in mechanical engineering, the physical properties and the microstructural phenomena characteristic to the individual material groups, with respect to the different heat treatment processes.

(3) Knowing the surface properties obtained by different methods of heat or thermochemical treatment to achieve thermal properties required for quality of work product.

Lecturers: Prof. Božidar Matijević, Prof. Darko Landek

Literature:

1. G. Krauss: Steel: Heat Treatment and Processing Principles, ASM International, Metals Park, USA, 1990.
2. C. H. Gür and J. Pan (ed): Handbook of Thermal Process Modeling of Steels, CRC Press, Taylor & Francis Group, 2009
3. B. Liščić, H.M. Tensi, L.C.F. Canale, G.E. Totten: Quenching Theory and Technology, 2nd Edition, CRC Press, 2010.
4. G. E. Totten: Steel Heat Treatment : Equipment and Process Design, 2nd ed. Boca Raton: Taylor & Francis, Portland, Oregon, USA, 2007.
5. Burakowski, T.; Wierzchon, T.: Surface Engineering of Metals, CRC Press LLC, 1999.
6. ASM Handbook: Volume 5: Surface Engineering, ASM International, Metal Park, USA, 1994.

ISVU Number: 156147

ECTS Credits: 6

Semester: winter

English Level: R2

Materials Science and Engineering

Course Description:

The course content: Introduction to materials science and engineering. Clasification of materials. Structure and imperfection of materials structure (metals, alloys, ceramics, glass, polymers and composite). Imperfection in the atomic and ionic arrangments. Atom and ion movements in materials. Mechanisms for diffusion and rate of difussion. Controling the microstructure and mechanical properties of engineering materials. Solid solution and phase diagrams of metal materials and ceramics. Equilibrium and nonequilibrium solidification. Processing of alloys, ceramics, polymers and composites. Relationship between properies and the phase diagram of engineering materials (metals, alloys, ceramics, glass, polymers and composite). Describe and compare the physical and mechanical properties of engineering materials. Understanding the reasons for changes in material properties by processing.

The course objectives: An interdisciplinary approach for relating the structure and properties of materials for engineering applications will be developed. Define the correlation between physical and mechanical properties and structure of the materials (metals, alloys, ceramics, polymers, composites). Controling the microstructure and mechanical properties of materials.

Lecturers: Prof. Lidija Ćurković, Prof. Krešimir Grilec

Literature:

1. D. R. Askeland, P. P. Phule, The Science and Engineering of Materials, Books/Cole-Thomson Learning, Pacific Grove, USA, 2003.
2. W. D. Callister, Jr., Materials Science and Engineering an Introduction, John Wiley & Sons, Inc., Danvers, USA, 2003.
3. V. Ivušić, M. Franz, Đ. Španiček, L. Ćurković, Materijali I, FSB, Zagreb, 2012.
4. T. Filetin, M. Franz, Đ. Španiček, V. Ivušić, Svojstva i karakteristike materijala, Katalog opisa, FSB, Zagreb, 2012.
5. W. F. Smith, Principles of Materials Science and Engineering, McGraw-Hill Publishing Company, New York, USA, 1990.
6. W. Soboyejo, Mechanical Properties of Engineered Materials, Marcel Dekker, Inc., New York, 2002.

ISVU Number: 156145

ECTS Credits: 6

Semester: winter

English Level: R2

Modeling in Materials Research

Course Description:

The objectives and content of the course are focused on the following topics:

(1) Understanding levels in material modeling into space-time scale, and application of proper methods: methods of statistical mechanics and thermodynamics; molecular dynamics methods; equilibrium and non-equilibrium thermodynamics methods; methods of fracture mechanic; -continuum methods (method of finite volumes, finite differences, finite elements and boundary elements); Monte Carlo methods; methods of phase field and cellular automata, artificial neural network methods; genetic algorithms and genetic programming methods.

(2) Application of thermodynamic and metallurgical methods and proper modeling methods for prediction of properties and material behavior in the following processes: crystallization, precipitation, re-crystallization and grain growth; sintering, microstructural phase transformations; diffusion of metal or/and nonmetal atoms; formation of carbides, nitrides, borides, oxides and similar compounds; deformation with formation of residual stresses; material fracture and creep; production processes; wear of surface layer,; corrosion.

(3) Planning, development and verification of the simulation model of changes in the material microstructure and properties.

(4) Preparation of scientific research paper in the field of materials modeling.

Lecturers: Prof. Darko Landek, Assoc. Prof. Irena Žmak

Literature:

1. Raabe, D., Roters, F., Chen, L.Q.: "Continuum Scale Simulation of Engineering Materials – Fundamentals – Microstructures – Process Applications", Wiley-VCH, 2004
2. Sidney, Y. (ed.): ''Handbook of Materials Modeling'', Part A, Part B, Springer, Dordrecht, erlin, Heidelberg, New York, 2005
3. Furrer, D.U., Semiatin, S.L. (ed.): ''ASM Handbook Vol. 22A: Fundamentals of modeling for Metals Processing" , ASM International, Metals Park OH, 2009
4. Furrer, D.U., Semiatin, S.L. (ed.): ''ASM Handbook Vol. 22B: Metals Processes Simulation", ASM International, Metals Park OH, 2010
5. Gür, C.H, Pan, J.: "Handbook of Thermal Process Modeling of Steels", CRC Press &Taylor & Francis Group, 2009.

ISVU Number: 156137

ECTS Credits: 6

Semester: winter

English Level: R2

Advanced Metal Construction Materials

Course Description:

The main objectives of the subject are to improve knowledge on contemporary metallic materials used in construction purposes, and inform about the latest trends in research, development and application of these materials and associated manufacturing processes. Identify their advantages and disadvantages in relation to the ″classical″ construction materials. Connect their properties to the microstructural condition, chemical composition and technological processing in order to create conditions for increased efficiency and quality. Thoroughly acquaint various groups of advanced materials such as steels for high and low temperatures and high strength steels. Get to know with modern tendencies in the development, producing and processing of new types of stainless steels: superaustenitic, superferritic, super-duplex and hyper-duplex steels. Analyze the properties and behavior of advanced non-ferrous alloys such as nickel-, titanium-and magnesium-alloys and superalloys and acquaint procedures their processing, thermal treatment, machining, joining ... Research would enable the development of new products with better performance and would also create conditions for increased efficiency of companies that own competitiveness based on the development and application of advanced materials.

Lecturers: Prof. Danko Ćorić, Prof. Vera Rede

Literature:

1. Novosel, M., Krumes, D.:, Posebni čelici, Strojarski fakultet, Slavonski Brod, 1998.
2. Advanced power plant materials, design and technology, Woodhead Publ. Ser. in Energy: Number 5, Edited by Dermot Roddy, Cambridge, UK, 2010.
3. D. Ćorić, T. Filetin: Materijali u zrakoplovstvu, Fakultet strojarstva i brodogradnje, Zagreb, 2012., Sveučilišni udžbenik
4. 4.Donachie, M. J., Donachie, S. J.: Superalloys – a technical guide, ASM International , Ohio, 2002.
5. 5.J. C. M. Farrar, The alloy tree – A guide to low-alloy steels, stainless steels and nickel-base alloys , Cambridge, 2004.
6. M. McGuire,Stainless steels for design engineers, ASM International Materials Park, Ohio, 2008.

ISVU Number: 156129

ECTS Credits: 6

Semester: summer/winter

English Level: R2

Advanced Tool Materials

Course Description:

The objectives and content of the course are focused on the following topics:

(1) Defining stresses, conventional and special, in the operation of particular groups of tools. Defining the requirements imposed on a tool material used for a specific purpose.

(2) Exploring particular groups of advanced tool materials fabricated by conventional and special processes to achieve desired chemical compositions and properties (metallic materials: ferrous, non-ferrous, sintered; hard metal, ceramic and composite tool materials).

(3) Exploring the latest heat treatment processes and procedures of modification and coating and their contribution to improving the tool properties.

(3) Based on un understanding of the composition, microstructure, and properties of these material, enable the selection of optimal tool material and heat treatment processes and/or surface modification and coating for given operating conditions and applications and assure the required quality of the product, efficient production and competitiveness.

Lecturers: Prof. Božidar Matijević, Prof. Darko Landek

Literature:

1. da Silva Farina, P. F.; Farina, A. B.; Barbosa, C. A.; Goldenstein, H. Proceedings of the 9th International Tooling Conference, Developing the World of Tooling, Montanuniversität Leoben, 11-14 September 2012.
2. Beiss, P. (editor): Proceedings of the 8th International Tooling Conference, TOOL 09: Tool Steels – Deciding Factor in Worldwide Production : RWTH Aachen University, Aachen, Germany, June 2-4, 2009, Verlag Mainz
3. Novosel, M., Cajner, F., Krumes, D.; Alatni materijali, Strojarski fakultet. Slavonski Brod 1996.
4. Bryson, W. E: Heat Treatment, Selection, and Application of Tool Steels 2nd edition, Hanser Publications, 2005
5. G.E. Totten (editor): ″Steel Heat Treatment: Metallurgy and Technologies″, 2nd. ed., CRC Press, USA, 2006

ISVU Number: 156127

ECTS Credits: 6

Semester: summer/winter

English Level: R2

Cellular Materials

Course Description:

Acquaintance with a cellular material, indication of the basic types and materials that are being produced. Preview nowadays known methods – methods of production. Detailed knowledge of the properties of cellular materials such as numerous mechanical, thermal, acoustic, electric and etc. Examples of application.

Lecturers: Prof. Krešimir Grilec, Assoc. Prof. Suzana Jakovljević

Literature:

1. Filetin T., Kramer I., Marić G.: Metalne pjene, HDMT, 2003.
2. Schwartz D.: Porous and cellular materials for structural applications. Materials Research Society, 1998
3. Ashby M.F., Evans A.G. & ostali: Metal Foams – A Design Guide. Butterworth-Heinmann, 2000.
4. Gibson l.J., Ashby M.F.,: Cellular solids: structure and properties. Cambridge Universitypress, 1997.
5. Degischer H.P., Kriszt B.: Handbook of Cellular Metals: Production, Processing, Applications, John Wiley & Sons, 2002.
6. Dukhan N.: Metal foams: Fundamentals an applications, DEStech Publications, Inc., 2013

ISVU Number: 156091

ECTS Credits: 6

Semester: summer/winter

English Level: R2

Composite materials

Course Description:

The objectives and content of the course are focused on the following topics: Insight into the structure and properties of composite materials, with special emphasis on advanced application site. Introduction to the micromechanics of composites and modeling and simulation. Fundamental technologies of components and composite products.

Lecturers: Prof. Zdravko Schauperl, Assoc. Prof. Tatjana Haramina

Literature:

1. William D. Callister, Jr. ,Materials Science and Engineering: An Introduction, John Wiley & Sons, Inc.
2. Broutman, L.J.; Krock, R.H.: Composite materials, Academic Press, New York.
3. Composites, Volume 21, ASM Handbook

ISVU Number: 156191

ECTS Credits: 6

Semester: summer/winter

English Level: R1

Engineering Ceramics

Course Description:

The course content: Ceramics materials, ceramics coating, glass, glass- ceramics. Raw materials and additives. Processing of specialty ceramics. Evolution and control of microstructure during sintering processes. Novel sintering processes. Imperfections of ceramic structure. Characterization techniques for ceramics materials and ceramics coating. Ceramics forming – aventage and disadventage of forming processes. Sintering of ceramics and influence on properties of final product. Mechanisms, types, corrosion rate and degradation properties of ceramics, glass and glass-ceramics. Mechanical properties of ceramic materials.

The course objectives: An interdisciplinary approach for relating the structure and properties of ceramics and ceramics coating for engineering applications will be developed. Introducion of new functional ceramic materials, ceramics coating, functional gradient ceramics, glass and glass-ceramics with examples of application. Knowledge of corrosion, corrosion mechanisms and degradation properties of ceramics, glass and glass ceramics. Explain the relationship between chemical composition, structure and properties of ceamics materials. Describe the difference between structure and properties of glass, ceramics and glass-ceramics.

Lecturers: Prof. Lidija Ćurković

Literature:

1. C. Barry Carter, M. Grant Norton, Ceramic Materials Science and Engineering,Springer, 2007.
2. Q. Yin, B. Zhu, H. Zeng, Microstructure, Property and Processing of Functional Ceramics, Springer, New York, 2009.
3. J. B. Wachtmanw, R. Cannonm, J. Matthewson, Mechanical Properties of Ceramics, John Wiley & Sons, Inc., USA, 2009.
4. R. A. Mc Cauley, Corrosion of Ceramic and Composite Materials, Marcel Dekker, Inc., New York, 2004.
5. B. M. Caruta (Editor), Ceramics and Composite Materials: New Research, Nova Science Publishers, Inc. New York, 2006.
6. Suk-Joong L. Kang, Sintering Densification, Grain Growth, and Microstructure, Elsevier, Amsterdam, 2005.

ISVU Number: 156152

ECTS Credits: 6

Semester: summer/winter

English Level: R2

Functional Materials

Course Description:

Introducing PhD students to the latest findings on materials with special properties, which have no mass application but apply where the properties of "classical" materials are not sufficient. Subject content includes an introducing to the shape memory alloys (SMA), the ferroelectric and ferromagnetic materials and their specific behaviour in a specific temperature ranges. Interpreting of dimensional changes through shape memory effects, magnetostriction and electrostriction. The correlation with the corresponding phase transformations. Introducing to different methods of characterization of specific properties of these materials. The research of features from the viewpoint of functional applications as the sensor or actuator. The main areas of application of functional materials and their advantages. The final aim of the subject is to educate PhDs who will have competence to analyse the properties and behaviour of functional materials, the development of new and optimizing already existing.

Lecturers: Prof. Danko Ćorić

Literature:

1. ASM Handbook : "Properties and Selection: Nonferrous Alloys and Special-Purpose Materials", Vol. 2, ASM, Ohio, 1990.
2. Deborah D. L. Chung: Functional Materials: Electrical, Dielectric, Electromagnetic, Optical and Magnetic Applications, World Scientific Publishing Co. Pte. Ltd., Singapore, 2010.
3. Shape Memory Alloys: Modeling and Engineering Applications, editor: D. C. Lagoudas, Springer, 2007.
4. Group of authors: Proceedings of the International Conference on Shape Memory and Superelastic Technologies – SMST 2004, Baden-Baden, Germany, 2004.
5. Shape Memory Materials, editors: K. Otsuka,C. M. Wayman, Cambridge University Press, 2002.
6. E. Hornbogen: Legierungen mit Formgedächtnis, Westdeutscher Verlag, Opladen, 1991.

ISVU Number: 156095

ECTS Credits: 6

Semester: summer/winter

English Level: R2

Materials and Environment

Course Description:

The content of the course covers the following topics: Adopting approaches to sustainable development, life cycle of products and materials, evaluation methods for environmental impacts of products and materials. Analysis of environmental impacts during all stages of a product's life cycle. Understanding of the embodied energy of a product or material. Material and energy evaluation of end-of-life (EoL) products. Understanding of processes and technologies for treatment of different types of waste products and materials. Studying design and materials selection principles, regarding to the product's life cycle. Studying the organization, procedures and effects of material recycling and product recovery. Testing the properties of recycled materials and products made using recycled materials.

Lecturers: Assoc. Prof. Slaven Dobrović, Assoc. Prof. Irena Žmak

Literature:

1. Ashby, M. F.: Materials and the Environment, Butterworth-Heinemann, 2009.

ISVU Number: 156121

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Materials Selection and Product Development

Course Description:

The content of the course covers the following topics: Analysis of the materials and product life cycle. Explanations of the relations between product development (product design), manufacturing technologies and materials. Application of the methodology of materials selection. Defining the requirements on products and materials as well as the criteria for selection of materials: functionality, exploitability (wear resistance, corrosion resistance), availability and cost, recyclability, standardization, tactility and aesthetic characteristics. Defining of relevant properties, merit parameters and functions for comparing and evaluation of materials. Introduction in the methods for materials selection and optimization. Critically use the computer aided systems for materials selection, data bases, information systems, CAMS and expert systems. Application of methods for materials selection for different structural and tool elements.

Lecturers: Prof. Vera Rede, Assoc. Prof. Irena Žmak

Literature:

1. T. Filetin, Izbor materijala pri razvoju proizvoda, Fakultet strojarstva i brodogradnje, Zagreb, 2006. Sveučilišni udžbenik

ISVU Number: 156120

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Mechanical Properties of Materials

Course Description:

The course content and objectives: Mechanical properties of materials have a special place among other physical and chemical properties, because on of their basis dimensions of machine parts are calculated. Considering of mechanical properties can be objectively evaluate the quality of the material and products. Mechanical properties of materials, as well as all other properties, are consequence of their structural state, which are obtained by treating the material of certain chemical composition with specific technological procedure. Thus, the selection of a particular material and appropriate technology result with specific structural state of the material and with desired properties. The emphasis of this course is the connection between the microstructure of metal polymer and ceramic materials with their mechanical properties. A detailed description of the methods for testing the mechanical properties as well as the analysis of the use of measurement equipment for testing follows. Particular attention is devoted to the field of metrology mentioned properties.

Lecturers: Prof. Emer. Mladen Franz, Assoc. Prof. Željko Alar, Prof. Danko Ćorić

Literature:

1. J.R. Davis: Tensile Testing, Second Edition, ASM International, 2004.
2. Richard S. Figliola, Donald E. Beasley: Theory and Design for Mechanical Measurements, fifth edition, John Wiley&Sons, 2011.
3. K. Hermann und 4 Mitautoren: Härteprüfung an Metallen und Kunststoffen, Grundlagen zu modernen Verfahren, 2007.
4. Filetin, T.; Franz, M.; Španiček, Đ.; Ivušić, V. Svojstva i karakteristike materijala – Katalog opisa . Zagreb : Fakultet strojarstva i brodogradnje, 2012.
5. Meyers, M., A., Kumar Chawla, K.: Mechanical Behavior of Materials, second edition, Cambridge University Press 2009.
6. Soboyejo, W.: Mechanical properties of Engineered Materials, Marcel Dekker, New York, 2003.

ISVU Number: 156118

ECTS Credits: 6

Semester: summer/winter

English Level: R1

Methods of Materials Characterization

Course Description:

The objectives and content of the course are focused on the following topics: Insight into the structure and properties of composite materials, with special emphasis on advanced application site. Introduction to the micromechanics of composites and modeling and simulation. Fundamental technologies of components and composite products.

Lecturers: Prof. Zdravko Schauperl, Prof. Vera Rede

Literature:

1. D. Brandon, W. D. Kaplan, Microstructural Characterization of Materials, England, 2008.
2. C. R. Brundle, C. A. Evans, Jr. S. Wilson, Encyclopedia of Materials Characterization, USA
3. E. N. Kaufmann, Characterization of Materials, New Jersey, 2003.
4. Yang Leng, Materials Characterization Introduction to Microscopic and Spectroscopic Methods, Singapore, 2008.
5. M. De Graef, M.l E. McHenry, Structure of Materials: An Introduction to Crystallography, Diffraction, and Symmetry, Cambridge, 2007.

ISVU Number: 156160

ECTS Credits: 6

Semester: summer/winter

English Level: R1

Nanostructured Materials

Course Description:

The course content: Introduction to nanoscience nanotechnology. Nanostructured materials. Properties and characterization of nanomaterials. Smart Coatings – Multilayered and Multifunctional in-situ Ultrahigh-temperature Coatings. Nanofluids: production, properties and applications. – Dispersion, synthesis and stabilization of colloidal solution, rheological properties of colloidal solutions. Methods for preparation of nanofluids: one-step and two-step method. Methods for synthesis nanoparticles: mechanical comminution (Top–Down methods) – high–energy ball milling and ultrasonication; Bottom-Up methods: sol-gel processing, solvothermal, hydothermal, coprecipitation and electrochemical processes. Nano-manufacturing, new trends and applications of nanomaterials. Nanotribology and nanomechanics: physical and mechanical properties.

The course goals: The presentation of the scientific knowledge in the field of the advanced methods synthesis of nanostructured materials. Indicate main areas of research in nanotechnology, the objectives of these studies, the assumptions underlying the use of analysis of nano structure, morphology and functional characteristics of nanomaterials. Describe production, properties and application of nanofluids, friction and wear on nanolevel.

Lecturers: Prof. Lidija Ćurković, Prof. Krešimir Grilec

Literature:

1. A. K. Bandyopadhyay, Nano Materials, New age international (P) Limited, New Delhi, 2008.
2. J. Ramsden, Nanotechnology, Jeremy Ramsden & Ventus Publishing ApS, 2009.
3. The American Ceramic Society, Progress in Nanotechnology Processing, John Wiley & Sons, Inc., Hoboken, New Jersey, 2010.
4. H. Hosono, Y. Mishima, H. Takezoe, K.J.D. MacKenzie: Nanomaterials: From Research to Applications, Elsevier BV, Amsterdam, The Netherlands, 2006
5. H. Paschen, C. Coenen, T. Fleischer, R. Grunwald, D. Oertel, C. Revermann: Nanotechnologie – Forschung, Entwicklung, Anwendung, Springer Verlag, 2004.

ISVU Number: 156144

ECTS Credits: 6

Semester: summer/winter

English Level: R2

Polymer Materials

Course Description:

The course content and objectives: Upgrading knowledge of polymer materials from the aspect of materials science and their applications in engineering and other related areas, detailed knowledge of the structure and properties of polymeric materials applicable in the mechanical engineering (thermoplastics, thermosetting plastics, thermoplastics and elastomers), and elaboration (selection and constructions) of some application examples.

Lecturers: Assoc. Prof. Tatjana Haramina

Literature:

1. R.A.L. Jones – Soft Condensed Matter, Oxford University Press (2003)
2. R.A.L. Jones – Polymers at Surfaces and Interfaces, Cambridge University Press (1999)
3. M.T. Shaw i W.J. MacKnight – Introduction to Polymer Viscoelasticity, Wiley-Interscience (2005)

ISVU Number: 156169

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Thermodynamic and Structure of Materials

Course Description:

The objectives and content of the course are focused on the following topics:

(1) Understanding and application of basic thermodynamic laws for the following purposes: determination of free chemical potential of clean substances and mixtures; -determination of activities of solutions; determination of equilibrium constants of chemical reactions; construction of phase diagrams; foresight of diffusion processes in metals and alloys; modeling of crystallization, precipitation, recrystallization and grain growth; determining surface energy and adsorption of particles on solid surface; foresight of diffusional phase transformations, description of process of formation of carbides, nitrides, borides etc., description of process forming of metallic foams; description of processes of heat transfer and wetting kinematic in heat treatment .

(2) Application of modern computer programs and databases for foresight of materials thermodynamic properties, phase diagrams and kinetic of chemical reactions.

(3) Solving problems with installation of thermal balance and kinetics of thermally activated processes in metals and alloys.

Lecturers: Prof. Darko Landek, Prof. Božidar Matijević

Literature:

1. Ragone, D., V.: Thermodynamic of materials, Vol. I, Vol. II, John Wiley & Sons, Inc, New York, Chichester, Brisbane, Toronto, Singapore, 1995
2. Gür, C.H, Pan, J.: ″Handbook of Thermal Process Modeling of Steels″, CRC Press &Taylor & Francis
3. Liščić, B., Tensi, H., Canale, L.C.F., Totten, G.E.: ″Quenching theory and technology″, CRC Press & Taylor and Francis Group,, Boca Raton, 2010

ISVU Number: 156189

ECTS Credits: 6

Semester: summer/winter

English Level: R2

Tribology

Course Description:

Studying of the mechanisms and processes of wear. Mastering the test methods for measuring tribological properties. Application of acquired knowledge in selecting tribological measures (surface modification and coating technologies, running-in, lubrication) which will reduce the wear of components in tribosystems. Training for independent decision-making in determining the optimum material from the viewpoint of tribology.

Lecturers: Prof. Krešimir Grilec, Izv. Suzana Jakovljević

Literature:

1. K. Grilec, S. Jakovljević, G. Marić: Tribologija u strojarstvu, Fakultet strojarstva i brodogradnje, 2017.
2. G.W. Stachowiak, A.W. Batchelor, Engineering Tribology, Elsevier, Amsterdam – London – New York – Tokyo, 1993.
3. K. Holmberg, A. Matthews, Coatings Tribology, Elsevier, Amsterdam – London – New York – Tokyo, 1994.
4. …., ASM Handbook, Vol. 18: Friction, lubrication and wear technology, ASM International, 1992.
5. T. Filetin, K. Grilec, Postupci modificiranja i prevlačenja površina, Priručnik za primjenu, Hrvatsko društvo za materijale i tribologiju, Zagreb, 2004.

ISVU Number: 156090

ECTS Credits: 6

Semester: summer/winter

English Level: R2

Study module:

Mechatronics and Robotics

List of fundamental elective courses of the doctoral study module:

1. Designing Mechatronic Systems
2. Methods of Automatization
3. Numerical Linear Algebra
4. Robotics

List of elective courses of the doctoral study module:

1. Advanced Computational Intelligence Systems
2. Computational Intelligence Algorithms
3. Digital Control Systems
4. Distributed Control Systems
5. Electrical Drives Control
6. Hydraulics and Pneumatics – Selected Topics
7. Intelligent Production Processes
8. Learning Methods and Programming of Autonomous Robotic Systems
9. Mobile Robots
10. Nanorobotics
11. Nonlinear Control Systems
12. Optimization Techniques in Control
13. Pneumatic and Hydraulic Servo Systems
14. Scientific Cloud Computing
15. Selected Topics of Computer Control
16. Sensorics

Designing Mechatronic Systems

Course Description:

The aim of the course is the research of principles and mechanisms that are used in automation and control of various systems. The topics of the course will enable the students to understand contemporary knowledge and tools that are utilized in the design of mechatronic systems. Throughout the course students will integrate modern knowledge and skills related to the mechanical design, electronics, control, modeling and simulation.

Lecturers: Prof. Bojan Jerbić, Prof. Mladen Crneković

Literature:

1. Jerbić, Bojan; Nikolić, Gojko; Vranješ, Božo; Kunica, Zoran. Projektiranje automatskih montažnih sustava . Zagreb : Kigen, 2009
2. R.H.Bishop, "The Mechatronics Handbook", CRC Press, 2002.
3. C.W.de Silva, "Mechatronics – an Integrated Approach", CRC Press, 2004.
4. Robotics: Modelling, Planning and Control (Advanced Textbooks in Control and Signal Processing); Bruno Siciliano, Lorenzo Sciavicco, Luigi Villani, Giuseppe Oriolo; Springer; 1st ed. 2009 edition (February 11, 2011); ISBN-13: 978-1846286414

ISVU Number: 156201

ECTS Credits: 6

Semester: winter

English Level: R1

Methods of Automatization

Course Description:

The main goals of the education in this subject are related to the presentation of the modern scientific knowledge in the region of the automatization proceses that includes the following contents. Control structures of technical systems. Computer control of robots and flexible manufacturing systems (FMS). Flexible model of distrubuted control. Optimal performance index analysis. Methods of optimal control. Optimal control of continuous dynamical systems. Optimal control of discrete dynamical systems. Synthesis of robust control systems. Control of nonlinear systems. Adaptive control systems. Synthesis of complex (large) dynamical systems: stability of the complex systems, decentralized control, structural composition and decomposition and synthesis of the structural control. Adaptive robot control. Control of the manufacturing systems. Control of flexible machining systems. Synthesis of the hierarchical coordinator of FMS. Intelligent control systems: artificial neural networks, fuzzy control systems and expert control systems.

Lecturers: Prof. Emer. Branko Novaković, Prof. Josip Kasać

Literature:

1. Novaković, Branko. Control methods for technical systems: applications to robotics, flexible systems and processes. Zagreb : Školska knjiga, 1990 (monography).
2. Novaković, Branko; Majetić, Dubravko; Široki, Mladen. Artificial neural networks / Filetin, Tomislav (ed.). Zagreb : FSB-University of Zagreb, Zagreb, 1998.
3. Moscinski and Z. Ogonowski. Advanced Control with Matlab and Simulink, Ellis Horwood, London, New York, 1995.
4. Novaković, Branko. Adaptive Fuzzy Logic Control Synthesis Without a Fuzzy Rule Base // Fuzzy Theory Systems – Techniques and Applications / Ed. by Leondes, Cornelius T., Forword by Zadeh, Lotfi A. (ed.). San Diego, London, Boston, New York, Sydney, Tokyo, Toronto : Academic Press, 1999. p. 781.
5. Kasać, Josip; Novaković, Branko; Majetić, Dubravko; Brezak, Danko. Parameters optimization of analytic fuzzy controllers for robot manipulators // Computer Aided Optimum Design in Engineering IX / S. Hernandez, C.A. Brebbia (ed.). Ashurst, Southampton : WIT Press, 2005. p. 10.
6. Kasać, Josip; Novaković, Branko. Neural Network Application to Optimal Control of Nonlinear Systems // Computer Aided Optimum Design of Structures VII / Hernandes, S. ; Brebbia, C.A. (ed.). Southampton, Boston : WIT Press, 2001. p. 10.

ISVU Number: 156099

ECTS Credits: 6

Semester: winter

English Level: R1

Numerical Linear Algebra

Course Description:

To understand concepts of the numerical linear algebra and scientific computing with emphasys how to choose a method for solution of the problem and the possible numerical errors in obtained results. Learn how to use the numerical libraries for solution of subproblems.

Lecturer: Prof. Sanja Singer

Literature:

1. James W. Demmel, Applied Numerical Linear Algebra, SIAM, 1997.
2. Lloyd N. Trefethen and David Bau, III, Numerical Linear Algebra, SIAM 1997.

ISVU Number: 155491

ECTS Credits: 6

Semester: winter

English Level: R2

Robotics

Course Description:

Prepare students for independent research work and creation of new knowledge and artifacts in the field of robotics. Introduction to modern methods of cognitive robotics, vision systems, group behavior and robot interaction in an unstructured environment. Principles of intelligent systems and their application in modeling and control of complex robotic systems.

A holistic rethinking of the role of robotics for the future of a civilization increasingly dependent on technology.

Lecturers: Prof. Mladen Crneković, Prof. Bojan Jerbić

Literature:

1. Siciliano, Khatib, Springer Handbook of Robotics, Springer 2008
2. Artificial Intelligence, A Modern Approach; Stuart Russell & Peter Norvig; secon edition; Pearson Education, New Jersey, 2003; ISBN 0-13-080302-2

ISVU Number: 156163

ECTS Credits: 6

Semester: winter

English Level: R2

Advanced Computational Intelligence Systems

Course Description:

Introduction to the structure and functioning principles of hybrid algorithms of computational intelligence based on the combinations of neural networks, fuzzy logic, genetic algorithms, swarm intelligence algorithms and/or support vector machines. Implementation of aforementioned algorithms and their hybrid forms using Field-programmable gate arrays (FPGA integrated circuits). Comparison and applications of advanced computational intelligence methods in classification, regression, prediction, signal filtration, system identification and control.

Lecturers: Assoc. Prof. Danko Brezak, Prof. Dubravko Majetić

Literature:

1. K.-L. Du, M.N.S. Swamy, Neural Networks in a Softcomputing Framework, ISBN: 978-1-84628-302-4, Springer-Verlag London Limited, 2006.
2. M. Negoita, D. Neagu, V. Palade, Computational Intelligence: Engineering of Hybrid Systems, ISBN 3-540-23219-2, Springer-Verlag Berlin Heidelberg, 2005.
3. O. Cordon, F. Herrera, F. Hoffmann, L. Magdalena, Genetic Fuzzy Systems, ISBN 981-02-4016-3, World Scientific Publishing, 2001.
4. H. T. Nguyen, N. R. Prasad, C. L. Walker, E. A. Walker, A First Course in Fuzzy and Neural Control, ISBN 1-58488-244-1, Chapman & Hall/CRC, 2003.
5. S. Hauck, A. DeHon (Ed.), Reconfigurable computing: the theory and practice of FPGA-based computation, ISBN 978-0-12-370522-8, Elsevier Inc., 2008.

ISVU Number: 156089

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Computational Intelligence Algorithms

Course Description:

Structure and functional characteristics of feed-forward and recurrent neural networks trained with supervised learning methods (multi-layer perceptron neural networks and their modifications, RBF neural network). Characteristics of neural networks trained with unsupervised learning methods (KSOM and ART neural networks). Advanced supervised and unsupervised neural network learning algorithms. Evaluation of neural network learning and test error. Fuzzy logic algorithms with and without fuzzy rule base. Mathematical models of genetic and swarm intelligence algorithms (particle swarm optimization and ant colony optimization). Support vector machine algorithms for classification and regression. Comparison and applications of analyzed algorithms in classification, regression and prediction.

Lecturers: Prof. Dubravko Majetić, Assoc. Prof. Danko Brezak

Literature:

1. B. Novaković, D. Majetić, M. Široki, Umjetne neuronske mreže (Artificial Neural Networks), ISBN 953-6313-17-0, Faculty of Mechanical Engineering and Naval
2. Architecture, Zagreb, 2011.
3. K.-L. Du, M.N.S. Swamy, Neural Networks in a Softcomputing Framework, ISBN: 978-1-84628-302-4, Springer-Verlag London Limited 2006.
4. V. Kecman, Learning & Soft Computing, Support Vector Machines, Neural Networks and Fuzzy Logic Systems, The MIT Press, Cambridge, MA, 2001.
5. M. Mitchell, An Introduction to Genetic Algorithms, The MIT Press, Cambridge, MA · London, England, 1999.
6. E. Bonabeau, G. Theraulaz, M. Dorigo, Swarm Intelligence: From Natural to Artificial Systems, ISBN 0-19-513158-4, Oxford University Press, 1999.

ISVU Number: 156107

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Digital Control Systems

Course Description:

The course includes topics in digital control through which the students will obtain relevant knowledge, competences and skills necessary for the discrete-time domain system analysis and signal processing, design of discrete-time controllers and estimators and control variable optimization. Within the course scope, an equal emphasis will be given to theoretical foundations and practical aspects of implementation of digital filters, controllers and estimators with the aim of developing key research and development skills in the field of mechatronic systems. Planned topics include: Discrete-time Fourier transform and Z transform. Digital filter design. PID controller design based on practical optima and numerical optimization tools; time-optimal controller design. State controller and estimator design. Design of generalized linear controller (polynomial controller). Linear predictive controllers (Smith predictor and generalized predictive controller). Process parameter estimators based on RLS method and adaptive Kalman filter. Auto-tuning controllers. Self-tuning controller and model reference adaptive controllers. Off-line numerical optimization of control variables with applications in mehatronic systems.

Lecturers: Prof. Joško Deur, Assoc. Prof. Danijel Pavković

Literature:

1. K. J. Astrom, B. Wittenmark: "Computer-controlled systems", 3rd ed., Prentice-Hall, 1997.
2. R. Isermann: "Digital Control Systems", Springer-Verlag, Berlin, 1989.
3. K. J. Astrom, B. Wittenmark: "Adaptive Control", 2nd ed., Addison-Wesley, Boston, 1989.
4. L. Ljung: "System Identification", Prentice-Hall, Englewood Cliffs, 1987.
5. F. Gustafsson: "Adaptive Filtering and Change Detection", John Wiley & Sons Ltd, 2000.
6. R. Soeterboek: "Predictive Control – A Unified Approach", Prentice-Hall Ltd., London, UK, 1992.

ISVU Number: 156057

ECTS Credits: 6

Semester: summer/winter

English Level: R1

Distributed Control Systems

Course Description:

Distributed control is a term used to denote a control structure in which each subsystem of a complex dynamical system is controlled by a single local controller, which in turn can communicate/coordinate its actions with (usually small) subset of the remaining local controllers in the system. Examples of such systems include: complex production systems; distributed parameter systems such as fluid dynamics and thermodynamics; control of mobile robots, aerial or road vehicles in a group; electrical power networks; transport networks (e.g. water supply), internet as dynamical system. In this class we will present a set of state-of-the-art approaches to distributed control. The covered topics include: formulation of distributed control goals; stability conditions; formulation of performance robustness; decomposition and coordination methods; distributed model predictive control. In addition, we cover a set of topics dealing with the problems of implementation of distributed control and distributed computing: grid and cloud computing; peer-to-peer network systems; clustering; network partition; , Service Level Agreements; Service-Oriented Networking (SON), Service-Oriented Architecture (SOA); Croatian national grid infrastructure (CRO NGI); Scriptrunner5 in distributed control.

Lecturers: Assoc. Prof. Andrej Jokić, Prof. Josip Kasać

Literature:

1. Boyd, S.; Vandenberghe, L.; "Convex Optimization", Cambrigde University Press, 2004.
2. Johannsonn, R.; Rantzer, A. (Edt.); "Distributed Decision Making and Control", Springer-Verlag, London, 2012.
3. Ren,W.; Cao, Y.; "Distributed Coordination of Multi-agent Networks", Springer-Verlag, London, 2011.
4. Gebali, Fayez; Algorithms and parallel computing, ISBN 978-0-470-90210-3,Copyright © 2011 by John Wiley & Sons, Inc.

ISVU Number: 156193

ECTS Credits: 6

Semester: winter/summer

English Level: R3

Electrical Drives Control

Course Description:

The course will include topics in electrical drive control through which the students will obtain relevant knowledge, competences and practical skills required for the design of electrical servodrives including those with complex transmission mechanisms, with applications to electric vehicle drives, electrical power systems and oil drilling systems. Even though the course is focused towards practical applications of servodrives, an equal emphasis will be given to firm theoretical foundations with the aim of developing essential competences for further research activities in mechatronic systems.

Planned topics include: DC and AC electrical machine dynamic models. Power converters and sensors in servodrives. Cascade control system structures for DC and AC drives. Current, speed and position controller design by means of practical optima. Advanced speed and position controller structures based on reference model. Adaptive controllers. Vibrations active damping. Servosystems. Friction and backlash compensation. Automotive applications of servodrives. Control of hybrid electric drives. Applications to renewable energy electrical power systems.

Lecturers: Prof. Joško Deur, Assoc. Prof. Danijel Pavković

Literature:

1. W. Leonhard: "Control of Electrical Drives", 3rd ed., 470 pp., Springer-Verlag, Berlin, Germany 2001.
2. B.K. Bose: "Power Electronics and AC Drives", Prentice Hall, Englewood Cliffs, N.J., USA, 1986.
3. P. Vas: "Sensorless Vector and Direct Torque Control", Oxford University Press, Oxford, UK, 1998.
4. K. J. Astrom, B. Wittenmark: "Computer-controlled systems", 3rd ed., Prentice-Hall, 1997.
5. T. K. Kiong, L. T.Heng, H. Sunan: "Precision Motion Control – Design and Implementation", 2nd ed., Springer-Verlag, London, UK, 2008.
6. J. Deur, D. Pavković: "Fundamentals of Electrical Drive Controls", UNESCO Encyclopedia of Life Support Systems, Chap. 6.39.21, 2012.

ISVU Number: 156058

ECTS Credits: 6

Semester: summer/winter

English Level: R2

Hydraulics and Pneumatics – Selected Topics

Course Description:

The aims of the course are to learn the student to apply hydraulics and pneumatics (fluid power systems) when solving his/her specific problem from automatisation, drive or transmission technology or energy storage. That is generally, how to apply fluid power when solving problems from mechatronics or robotics. The course is assumed so it can be adjusted to the student's main task or generally to his/her research scope and also to his/her background in fluid power. Namely, the student in his/her initial research imposes general requirement which should be satisfied by the drive or transmission system. Then the teacher on dedicated lectures and seminars reads the basic assumptions and methods of the problem solving using fluid power. Than the student is instructed to solve the problem by himself/herself. Contents of the course: the study of actual topics from fluid power is stimulated. That can be for instance energy efficient systems (variable flow controlled), hybrid hydraulic vehicles, transient energy storage, digital pumps and valves, pneumatic suspensions and brakes.

Lecturers: Prof. Željko Šitum

Literature:

1. J. Petrić: Hidraulika, web izdanje udžbenika
2. G. Nikolić, Pneumatika i elektropneumatika, Zrinski Čakovec, 2007.
3. D. Siminiati, Uljna hidraulika, Sveučilište u Rijeci, 2012.
4. N. D. Manring, Hydraulic Control Systems, Wiley, 2005.
5. G. R. Keller, Hydraulic System Analysis, Penton, 1985.

ISVU Number: 156186

ECTS Credits: 6

Semester: summer/winter

English Level: R2

Intelligent Production Processes

Course Description:

Introduction and consideration of constantly present phenomena of production and automation in technical and non-technical areas: state, trends and paradigms (technical, biological and socio-cultural). Focusing on problems such as establishing functionality or discreet handling during assembly, disassembly and packaging, mastering the knowledge – approaches, methodologies and procedures – required to implement a production system of appropriate degree of automation, which includes: selection and analysis of problem solving expediency; selection and design of production system components; integration of components into the system; system management and programming; fitting the production system into a broader socio-cultural context. By attending the course, the student is trained for independent scientific research work: further development of approaches and methods of improving production and achieving higher levels of automation of specific products and activities.

After successfully attending the course, the student will be able to: 1. select and valorize a specific potential area for the implementation of automation; 2. select process design procedures; 3. set priorities in the implementation of automation; 4. design, evaluate and recommend technical process solutions of an appropriate degree of automation; 5. review existing and develop new approaches, procedures and tools.

Lecturers: Prof. Zoran Kunica, Asst. Prof. Petar Ćurković, Asst. Prof. Tomislav Stipančić

Literature:

1. Valentino Braitenberg: Vehicles: Experiments in Synthetic Psychology, MIT Press, 1986.
2. Geoffrey Boothroyd, Peter Dewhurst, Winston A. Knight: Product Design for Manufacture and Assembly, CRC Press, 2010.
3. Alexandre Dolgui, Jean-Marie Proth: Supply Chain Engineering: Useful Methods and Techniques, Springer, 2010.
4. Sunderesh Heragu: Facilities Design, CRC Press, 2008.
5. Biren Prasad: Concurrent Engineering Fundamentals: Integrated Product and Process Organization, Volume I, 1996.
6. Maja J. Matarić: The Robotics Primer (Intelligent Robotics and Autonomous Agents series), MIT Press, 2007.
7. Eric Berne: Games People Play: The Basic Handbook of Transactional Analysis, Ballantine Books, 1996.

ISVU Number: 156094

ECTS Credits: 6

Semester: summer/winter

English Level: R2

Learning Methods and Programming of Autonomous Robotic Systems

Course Description:

The aim of the course it to research and to study the principles of autonomous intelligent systems. The topics will introduce modern methods of robotic intelligence and intelligent contro such as: the application of probability theory to model inference and decision making, adaptive control and its application in the control of complex robotic systems. The topics will also cover and introduce modern controllers, and control tools.

Lecturers:. Prof. Bojan Jerbić

Literature:

1. Artificial Intelligence, A Modern Approach; Stuart Russell & Peter Norvig; secon edition; Pearson Education, New Jersey, 2003; ISBN 0-13-080302-2
2. Sebastian Thrun, Wolfram Burgard and Dieter Fox (2006): Probabilistic Robotics. London: MIT Press
3. Robotics, Vision and Control: Fundamental Algorithms in MATLAB; Peter Corke; Springer; 1st ed. 2011. Corr. 3rd printing 2012 edition (March 1, 2013); ISBN-13: 978-3642201431
4. Robotics: Modelling, Planning and Control (Advanced Textbooks in Control and Signal Processing); Bruno Siciliano, Lorenzo Sciavicco, Luigi Villani, Giuseppe Oriolo; Springer; 1st ed. 2009 edition (February 11, 2011); ISBN-13: 978-1846286414
5. Adnan Darwiche (2009): Modeling and Reasoning with Bayesian Networks. New York: Cambridge University Press

ISVU Number: 156184

ECTS Credits: 6

Semester: summer/winter

English Level: R1

Mobile Robots

Course Description:

Introduce the student to current research in the field of mobile robots and their importance for the future of our civilization. Instruct the student in the classification of problems and methods of solving various aspects of mobile robots.

To train students for independent research work in the field of mobile robots.

Lecturers: Prof. Mladen Crneković

Literature:

1. Siciliano, Khatib, Springer Handbook of Robotics, Springer 2008
2. M. Crneković, User manual for eMIR mobile robot, FSB

ISVU Number: 156098

ECTS Credits: 6

Semester: summer/winter

English Level: R2

Nanorobotics

Course Description:

The main goals of the education in this subject are related to the presentation of the modern scientific knowledge in the region of the nanorobotics that includes the following contents. Dynamic model of nanorobot motion in multipotential field. Coordinate transformation in nanorobotics. Some problems and solutions in nanorobot control. Control of nanorobot motion in a multipotential field. Application of Schrödinger equation to an alpha field in nanorobotics. Derivation of Hamilton functions including artificial control field in nanorobotics.

Lecturers: Prof. Emer. Branko Novaković, Prof. Dubravko Majetić

Literature:

1. Requicha, A. A. G., 2008 , Nanorobotics , Laboratory for Molecular Robotics and Computer Science Department, University of Southern California, LosAngeles,CA90089-0781requicha@usc.edu, web-site http://www-lmr.usc.edu/~lmr, 2008.
2. Gómez – López, M. , Preece, J. A. and Stoddart J. F., 1996, The art and science of self-assembling molecular machines, Nanotechnology, Vol. 7, No. 3, pp. 183-192, Sept. 1996.
3. Gómez – López, M. , Preece, J. A. and Stoddart J. F., 1996, The art and science of self-assembling molecular machines, Nanotechnology, Vol. 7, No. 3, pp. 183-192, Sept. 1996.
4. Novaković, Branko; Majetić, Dubravko; Kasać, Josip; Brezak, Danko.
5. Control of Nanorobot Motion in a Multipotential Field // Computer Integrated Manufakcturing and High Speed Machining / E. Ebele ; T. Udiljak ; D. Ciglar (ur.). Zagreb : DENONA d.o.o., Zagreb, 2011. 159-166.
6. Novaković, Branko; Majetić, Dubravko; Kasać, Josip; Brezak, Danko: Application of Schrödinger Equation to an Alpha Field in Nanorobotics // ECCM 2010 – IV European Conference on Computational Mechanics / Allix, O. ; Wriggers, P. (ur.). Paris : ECCOMAS – 2010. 90-1-90-2.

ISVU Number: 156104

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Nonlinear Control Systems

Course Description:

The main goal of this course is introduction to modern methods of analysis and design of nonlinear control systems. The course is divided into three main parts: analysis, qualitative properties and design of nonlinear control systems. In the first part of the course the following method of analysis will be considered: perturbation analysis, Adomian decomposition method, homotopy perturbation method, Carleman linearization. In the second part of the course the following qualitative properties will be considered: controllability and observability of nonlinear systems, Lyapunov stability, passivity of nonlinear systems, Lp stability, port-controlled Hamiltonian realization of nonlinear systems. In the third part of the course the following control design methods will be considered: feedback linearization, integrator backstepping design, sliding-mode control, passivity-based control, iterative and repetitive learning control. Also, the control methods for the special classes of systems like multiagent systems and distributed parameter systems will be considered.

Lecturers: Prof. Josip Kasać, Prof. Emer. Branko Novaković

Literature:

1. H. Khalil, Nonlinear Systems, 3rd ed., Prentice Hall, New Jersey, 2002.
2. H. J. Marquez, Nonlinear Control Systems – Analysis and Design, John Wiley & Sons, Inc., New Jersey, 2003.
3. J. J. E. Slotine & W. Li, Applied Nonlinear Control, Prentice Hall, New Jersey, 1991.
4. V. Utkin, J. Guldner & J. Shi, Sliding Mode Control in Electro-Mechanical Systems, 2nd ed., Taylor & Francis, New York, 2009.
5. F. Lin, Robust Control Design – An Optimal Control Approach, John Wiley & Sons Ltd, New Jersey, 2007.

ISVU Number: 156135

ECTS Credits: 6

Semester: summer/winter

English Level: R1

Optimization Techniques in Control

Course Description:

Advances in the field of optimization theory over past two decades have made a significant impact on the development of novel elements in control systems theory as well as constructive numerical algorithms for analysis/synthesis of dynamical systems. Particularly important impact has development of efficient numerical algorithms for solving optimization problems subject to linear matrix inequalities. The main goal of this class to learn the basic, fundamental theory as well as the relevant state-of-the-art results from the field of (robust) convex optimization; to present how to systematically use these results in formulation of large set of important control systems problems, and to present constructive algorithmic methods for their solution.

In some more detail, the topics and the goals of the class are summarized as follows: Convex optimization basics; Linear matrix inequalities; Stability and an optimization problem; Dynamical performance as an optimization problem; Synthesis of optimal controllers; Robust optimization and higher order relaxations; Multiobjective optimization in control system synthesis.

In addition to gaining knowledge of the basic theoretical foundations, the students will be acquainted with suitable available software tools while a number of practical examples will be presented.

Lecturer: Assoc. Prof. Andrej Jokić

Literature:

1. Dullerud, G.E.; Paganini, F.G.; "A Course in Robust Control Theory, A Convex Approach", Springer, 2005.
2. Boyd, S.; Vandenberghe, L.; "Convex Optimization", Cambrigde University Press, 2004.
3. Scherer, C.W.; Weiland, S.; "Linear Matrix Inequalities in Control", Lecture Notes, Dutch Institute for Systems and Control, The Netherlands, 2000.
4. Boyd, S.; El Ghaoui, L.; Feron, E.; Balakrishnan, V.; "Linear Matrix Inequalities in System and Control Theory", Society for Industrial and Applied Mathematics (SIAM), 1994.

ISVU Number: 156176

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Pneumatic and Hydraulic Servo Systems

Course Description:

The aim of this course is to extend learners' knowledge and understanding of fluid power systems control through theoretical instruction and hands-on exercises of building fluid power circuits and observing how they operate. Special focus will be given to the operating principles of proportional and servo hydraulic and pneumatic systems, their basic structure and practical applications. The unit will also deal with the representation of multivariable dynamic systems, modern methods in fluid power systems control and implementation of control algorithm in time-discrete domain. Learners should also use modern modelling and simulation tools (Matlab/Simulink, LabVIEW) to the analysis and synthesis of real-time feedback control.

Lecturers: Prof. Željko Šitum

Literature:

1. Hydraulic Servo–systems: Modelling, Identification and Control, M. Jelali and A. Kroll, Springer–Verlag, 2003.
2. Servohydraulik – Geregelte hydraulische Antriebe, H. Murrenhoff, Shaker–Verlag, 2008.
3. Designer's Handbook for Electrohydraulic Systems, Johnson, J.L., IDAS Eng., 2000.
4. Hydraulic Control System, H.E. Merritt, John Wiley, New York, 1967.
5. Pneumatic Drives: System Design, Modelling and Control, P. Beater, Berlin: Springer-Verlag, 2007.
6. Dorr H., et. all. The Hydraulic Trainer Volume 2, Proportional and Servo Valve Technology, Mannesmann Rexroth GmbH.

ISVU Number: 156113

ECTS Credits: 6

Semester: summer/winter

English Level: R2

Scientific Cloud Computing

Course Description:

″Cloud computing″ is a paradigm of the new generation of the Internet, which is making a fundamental transformation of the entire IT and the present work with computers – from the business world to science. It is a new type of virtualization that has its foundation in grid technology and open-source approach (OpenNebula, OpenStac, Apache Hadoop). Existing programs in various scientific fields (electrical engineering, mechanics, thermodynamics, etc.) will need to adapt to the new, collaborative conditions. The course provides a theoretical and practical framework for the change through the underlying technology: P2P (Aneka, Bellagio, condorFlock), Grid (InterGrid, MOSIX-FED, Tycoon) and Cloud (Amazon EC2, Azure, Eucalyptus). They learn the basics of ″cloud″ models: Infrastructure-as-a-Service (IaaS), Platform-as-a-Service (PaaS), Software-as-a-Service (SaaS) – Google AppEngine, Apps, Docs, and SOA Dr. and partially centralized and distributed network management (JXTA). Lectures and exercises in the scientific cloud computing are conducted through Scriptrunner, Croatian web / cloud system that stores and carry out programs of most programming languages and scientific tools remotely and integrates other scholarly Web Systems (R / RStudio, SAGE, OpenCPU, Sphinx, etc .).

Lecturers: Assoc. Prof. Tomislav Stipančić, Assoc. Prof. Vladimir Milić

Literature:

1. Sosinsky, Barrie, Cloud Computing Bible, ISBN: 978-0-470-90356-8, 2011 by Wiley Publishing, Inc.
2. Sarna, David E. Y., Implementing and developing cloud computing applications, ISBN 978-1-4398-3082-6, 2011 by Taylor and Francis Group, LLC
3. Buyya,Rajkumar; Broberg, James; Goscinski, Andrzej; Cloud computing : principles and paradigms, ISBN 978-0-470-88799-8, 2011 by John Wiley & Sons, Inc.
4. Langtangen, Hans Petter; A Primer on Scientific Programming with Python, ISBN 978-3-642-30293-0, 2012 by Springer Heidelberg
5. Preve, Nikolaos P., Grid Computing – Towards a Global Interconnected Infrastructure, ISBN 978-0-85729-676-4, 2011, Springer-Verlag London Limited
6. Langer, Ulrich; Paule, Peter; Numerical and Symbolic Scientific Computing, ISBN 978-3-7091-0794-2, 2012, Springer-Verlag/Wien

ISVU Number: 156048

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Selected Topics of Computer Control

Course Description:

The main goal of the subject is to present: Basic concepts of industrial computing. Mathematical foundations for the design of computer control systems with mechatronics and robotics applications.

The aforementioned topics include the following sub-topics: Advanced microprocessor structures, RISC and CISC architectures, digital signal processors (DSPs), multi-processor systems. Working with input-output peripherals (A/D and D/A converters, digital I/O, incremental encoder signal counters, PWM generators). Industrial communication devices and standards. Specialized higher-level programming languages for control applications (C/C++, STEP 7, LabView, Matlab). Visualisation systems. Control object description in discrete-time domain. State-space models. Advanced controller structures. Implementation of digital controller. Computer control of robots and flexible manufacturing systems.

The aforementioned topics are required for the attaining of necessary theoretical background and practical knowledge and skills in order to enable the participant to independently design and develop the microcontroller systems and related program support both in research and practical applications in mechatronic systems.

Lecturers: Prof. Davor Zorc, Assoc. Prof. Danijel Pavković

Literature:

1. C.L. Phillips, H.T. Nagle: "Digital control systems, Analysis & Design", Mc-Graw Hill Int., 1994
2. K. J. Astrom, "Computer-controlled systems", Prentice-Hall, 1984.
3. P. Lapsley, J. Bier, A. Shohamm, E.A. Lee: "DSP Processor Fundamentals", IEEE Press, 1997.
4. T. Šurina, M. Crneković: "Industrijski roboti", Školska knjiga, Zagreb, 1990.
5. S. Ribarić, Arhitektura RISC i CISC računala, Školska knjiga, Zagreb, 1996.
6. D. Reynolds, S. Mackay, E. Wright: "Practical Industrial Data Communications", Elsevier, 2005.

ISVU Number: 156158

ECTS Credits: 6

Semester: summer/winter

English Level: R1

Sensorics

Course Description:

To present the following topics in sensorics: Systematization of sensors according to different classification criteria. Information model of sensor, and its static and dynamic characteristics. Error analysis and calibration procedures. Overview of physical principles of measurement conversion. Specific features of mechanical quantity sensors. Basic structures. Systematization of sensor output signals. Primary signal processing. Analyses of modulation and demodulation methods. Digital sensors. Microsensors. Intelligent sensor concepts and sensor functionality extension. Criteria for sensor selection. Sensor reliability. Sensor development trends.

The above topics are aimed at attaining both the theoretical knowledge in the field of measurement systems and sensorics, as well as honing the practical skills of the participant, required for the in-depth analysis, design and implementation of advanced measurement and instrumentation systems both in research and practical (field) applications.

Lecturers: Prof. Davor Zorc, Assoc. Prof. Danijel Pavković

Literature:

1. Popović, M.: Senzori i mjerenja, Svjetlost, Sarajevo, 1992.
2. M. Brezinšćak, Mjerenje i računanje u tehnici i znanosti, Tehnička knjiga, Zagreb, 1971.
3. J. G. Webster: ''Measurement and Instrumentation Sensors Handbook'', CRC Press, 1999.
4. J. Fraden: ''Handbook of Modern Sensors: Physics, Designs, and Applications'', 3rd edition, Springer, 2003.

ISVU Number: 156157

ECTS Credits: 6

Semester: summer/winter

English Level: R1

Study module:

Metallurgical Engineering

List of fundamental elective courses of the doctoral study module:

1. Advanced Physical Metallurgy
2. Numerical Linear Algebra
3. Solidification and As-cast Microstructure Evolution
4. Theory of Metal Forming Process

List of elective courses of the doctoral study module:

1. Advanced Methods of Metal Research
2. Aluminum Alloys Casting
3. Corrosion of Structural Steels
4. Deformation Properties of Metals and Alloys
5. Energy Efficiency of Industrial Furnaces
6. Environmental Emissions from Iron and Steel Metallurgy
7. Innovative Processes of Metal Casting
8. Leaching Processes in Hydrometallurgy
9. Mathematical Modelling of Industrial Furnaces
10. Metallurgy of Aluminum
11. Metallurgy of Cast Irons and Steels
12. Modern Methods of Chemical Analysis in Metallurgy
13. Phase Transformations in Metallic Materials
14. Special Alloys
15. Theory of Metallurgical Processes
16. Waste and By-products from the Metallurgical Industry
17. Welding Metallurgy

Advanced Physical Metallurgy

Course Description:

Real and reciprocal crystal lattices. Symmetry in crystals. Diffraction and scattering of the crystal structure. Electron in a periodic potential. Fermi-Dirac distribution. Bloch's model. Many-body effects and cohesive energy. Conductivity, semiconductors, and superconductivity. Magnetism in materials. Electromagnetic waves in materials. Diffusion. Recovery, recrystallization, and grain growth. Material characterization. Phase transformations, state stability. TTT diagrams. Transformation of austenite at slow cooling. Phase changes in non-equilibrium cooling of steel. Hardening of metals. Heat treatment. The goal is to provide a physical basis for the relation of the alloy and metal structure, and their properties.

Lecturers: Prof. Stjepan Kožuh, Assoc. Prof. Robert Pezer, Assoc. Prof. Ljerka Slokar Benić

Literature:

1. R.W. Cahn, P. Haasen, Physical Metallurgy, Elsevier Science, Amsterdam, 1996
2. Anil Kumar Sinha, Physical metallurgy handbook, New York : McGraw-Hill, 2003.
3. E.J. Mittemeijer, Fundamentals of Materials Science, Springer, Berlin, 2010

ISVU Number: 156068

ECTS Credits: 6

Semester: winter

English Level: R2

Numerical Linear Algebra

Course Description:

To understand concepts of the numerical linear algebra and scientific computing with emphasys how to choose a method for solution of the problem and the possible numerical errors in obtained results. Learn how to use the numerical libraries for solution of subproblems.

Lecturer: Prof. Sanja Singer

Literature:

1. James W. Demmel, Applied Numerical Linear Algebra, SIAM, 1997.
2. Lloyd N. Trefethen and David Bau, III, Numerical Linear Algebra, SIAM 1997.

ISVU Number: 155491

ECTS Credits: 6

Semester: winter

English Level: R2

Solidification and As-cast Microstructure Evolution

Course Description:

The phenomena during the solidification of metals and considerations of particular phenomena in length scale solidification structures: nano, micro, meso, macro scale. Thermodynamic conditions of the solidification process, the free energy change as a driving force for solidification, the criterion of heterogeneous equilibrium. The principal types of binary alloy solidification. Nucleation, interface-controlled process involving an activation energy which is affected by the presence of catalyst, nucleation kinetics. Crystal growth from the melts, interfacial instability of solidification plane front, perturbation analysis, interface structure and growth kinetics, entropy of fusion ΔSf, growth of faceted and non-faceted crystals. Microstructure evolution, growth of cells and dendrites, growth of eutectics, regular and irregular eutectics, the competitive growth of eutectic and dendrites, divorced and coupled eutectic growth zone. Constitutional under cooling, effect of solute components and solidification conditions (temperature gradient) on the morphology of the phases. Structural zone formation in casting, the solidification morphology of multicomponent engineering alloys. Correlation between microstructure and mechanical properties. Modern conceptions of microstructure refinement of multicomponent engineering alloys (melt inoculation and modification). Nonequilibrium solidification, Gulliver-Scheil equation of solute component redistribution during the solidification. Macro and micro segregations. Effect of solidification time and cooling range (10-5 – 1010 K/s) on as-cast microstructure: segregations, precipitations of phases and shrink micro cavities in last solidifying zones. Quality of the melts and solidification control, computer aided thermal analysis. Microstructure and mechanical properties optimization of the casting components by control of the processing variables.

Lecturers: Assoc. Prof. Zdenka Zovko Brodarac, Prof. Primož Mrvar, Prof. Zoran Glavaš

Literature:

1. M. E. Glicksman, ″Principles of Solidification″, Springer, Science+Business Media, 2011.
2. D. M. Stefanescu, ″Science and Engineering of Casting Solidification″, 2nd Ed., Springer, Science+Business Media, 2009.
3. J. E. Gruzleski, ″Microstructure Development during Metalcasting″, American Foundrymen's Society INC., Des Plaines, Ilinois, USA, 2000.

ISVU Number: 156078

ECTS Credits: 6

Semester: winter

English Level: R3

Theory of Metal Forming Process

Course Description:

Theory of deformation. Theory of elasticity. Theory of plasticity. Deformation zone and stress distribution in the deformation zone. Influencing parameters on plasticity. Limitations, applicability and usability of different methods of process analysis of metal forming. Interactions of research systems. Physical modelling and simulation. Numerical modelling of deformation processes. The review of the theory of similarity in some procedures of metal forming. Fundamentals of the finite element method applied to examples of metal forming processes. Introduction to modern methods of analysis of large plastic deformations, physical and numerical modelling of formation operation, applying of available software in the analysis of forming operations by deforming. The course objective is to clarify the mechanisms of elastic and plastic deformation, to clarify the distribution of stresses in the deformation zone, show the applying of physical and mathematical modelling in real conditions.

Lecturers: Prof. Stoja Rešković, Asst. Prof. Martina Lovrenić Jugović

Literature:

1. I. Mamuzić, Teorija, materijali, tehnologija čeličnih cijevi, Hrvatsko metalurško društvo, Zagreb 1996.
2. D. Mazumdar, J.W. Evans, Modeling of Steelmaking Processes, CRC Press, 2010.
3. A. Povrzanović, Obrade metala deformiranjem, FSB Zagreb, 1996.
4. I. Mamuzić, Teorija, materijali, tehnologija čeličnih cijevi, Hrvatsko metalurško društvo, Zagreb 1996.

ISVU Number: 156063

ECTS Credits: 6

Semester: winter

English Level: R2

Advanced Methods of Metal Research

Course Description:

Metallography. Light and electron microscopy (SEM, TEM, EBSD). X-rays diffraction analysis. Quantitative analysis of microstructure. Spectroscopy (EDS, WDS etc.).

Thermal analysis techniques: dilatometry, differential scanning calorimetry (DSC), differential thermal analysis (DTA), thermogravimetry (TG), dynamical mechanical analysis (DMA), thermomechanical analysis. Infrared spectroscopy with Fourier transformation. Surface analytical methods (AES, XPS etc.)

The main objectives of the course are: to obtain detailed information about the microstructure of metal materials, directly connecting the microstructure with functional properties of the material, the prediction of material properties based on the microstructure.

Lecturers: Assoc. Prof. Tamara Holjevac Grgurić, Assoc. Prof. Ljerka Slokar Benić

Literature:

1. C.R. Brundle, C.A. Evans, S. Wilson, Encyclopedia of Materials Characterization, Butterworth-Heinemann, Boston, 1992
2. A.R. Clarke, C.N. Eberhardt, Microscopy Techniques for Materials Science, Woodhead Publishing Limited, Cambridge, 2002.
3. Materials Characterization, ASM Metals Handbook Volume 10, ASM International, 1998
4. P.J.Heines, Thermal Methods of Analysis, Principles and Aplication, Blackie Academic & Professional, New York, 1995.

ISVU Number: 156067

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Aluminum Alloy Casting

Course Description:

Classification of aluminum alloys. Solidification of aluminum alloys. Thermodynamic conditions of solidification. Fundamentals of nucleation. Models of primary grain initiation. Theory of crystal growth. Growth restriction factor. Effect anddistributionof soluteelements.

Primary microstructure development of aluminium alloy and solidification mode of aluminum alloys. Eutectic solidification with practice examples.

Determination of nucleation potential, sequence and kinetics of aluminum alloys solidification. Grain morphology in primary microstructure (segregation) in aluminium alloys with practice examples.

An influence of alloying and trace elements in aluminum alloys on mechanical and technological properties of the casting. An influence of impurities. Secondary aluminium as charge material. The most common aluminum systems, the interpretation of the equilibrium phase diagram. Predicting of the metallurgical parameters impact in real conditions of cooling and solidification on the microstructure and properties of the aluminum alloys.

Melt treatment of aluminum alloys (degassing, filtration, inoculation, modification). Overview of the most common applied resources for inoculation and modification and their properties.

Aluminum alloys casting processes for:industrial processes, gravity casting, low-and high-pressure die casting, vacuumcasting, the semi-solid state casting, special casting processes. Test methods and quality control of aluminum alloy melt and castings. Defects in aluminium castings.

Course objectives: Adoption of modern theoretical insights related to solidification of aluminum alloys. Correlation of melt processing parameters and primary solidification microstructure development with achived properties of aluminum castings. Control and quality assurance of casting aluminum alloy.

Lecturer: Assoc. Prof. Zdenka Zovko Brodarac

Literature:

1. D. M. Stefanescu, Science and Engineering of Casting Solidification, Kluwer Academic/ Plenum Publishers, New York, 2002.
2. W. Kurz, D. J. Fisher, Fundamentals of Solidification, Trans Tech Publication, Aedermannsdorf, Switzerland, 1986.
3. J. E. Gruzleski, Microstructure Development during Metalcasting, American Foundrymen's Society INC., Des Plaines, Ilinois, USA, 2000.

ISVU Number: 156076

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Corrosion of structural steels

Course Description:

Course objectives: To know and understand the basic principles of chemical, electrochemical and chemical-mechanical degradation of structural steels. Get acquainted with the types of structural steels for special purposes in aggressive application conditions.

Course content (syllabus): Thermodynamics and kinetics of high temperature corrosion processes of structural steels. Thermodynamics and kinetics of corrosion of structural steels in aqueous solutions. General and local corrosion (pitting, intercrystalline, transcrystalline corrosion) of structural steels. Special forms of corrosion of structural steels: stress corrosion cracking – SCC, sulfide stress corrosion cracking – SSCC, hydrogen embrittlement-HE, contact corrosion, corrosion in joints, corrosion fatigue, erosion, cavitation. Influence of microstructure on steel corrosion (OCTG, HSLA, TMCP, DP, TRIP, IF) for oil and automotive industry.

Lecturer: Assoc. Prof. Anita Begić Hadžipašić

Literature:

1. H2S Corrosion in Oil and Gas Production, Vol. I, Vol. II, (R.N. Tuttle, R.D. Kane, eds.), NACE, Houston, 2000.
2. ASM Corrosion Handbook, Vol. 13B, 2006, ASM International, Materials Park, OH.
3. I. Esih, Z. Dugi, Technology of corrosion protection (in Croatian: Tehnologija zaštite od korozije), Školska knjiga, Zagreb, 1990.

ISVU Number:156080

ECTS Credits: 6

Semester: summer/winter

English Level: R2

Deformation Properties of Metals and Alloys

Course Description:

Specifics plasticity and deformation resistance of metals and alloys. Research plasticity and resistance to deformation. Thermomechanical processing and interaction mechanisms of deformation strengthening and softening. Elaboration of symmetric andasymmetric rolling process. Rheological similarity of metals and alloys. The study of the deformation rheological behavior of composite materials. Rheological distribution of materials and rheological condition of deformation zones in the process of forming. Mathematical models of complex rheological deformation of metals and alloys. The aim of the course is to clarify the influence of conditions and parameters on deformation plasticity and deformation resistance of composite materials for the determination of physical and mathematical parameters of deformation.

Lecturers: Prof. Stoja Rešković

Literature:

1. G.G. Shlomchack, I. Mamuzić, F. Vodopivec, Rheological Similarity of Metals and Alloys, Journal of Materials Processing Technology, 40 (1994) 315-325.
2. G.G. Shlomchack, I. Mamuzić, A.A. Milenin, F. Vodopivec, A Mathematical Model of the Process of Plastic Deformation Zone in the Tolling of Rheological Complex Metals and Alloys , Journal of Materials Processing Technology 42 (1994) 6, 515-521.
3. H. Pawelski, O. Pawelski, Technische Plasto Mechanik, Verlag stahleisen Gmbh,

ISVU Number: 156064

ECTS Credits: 6

Semester: summer/winter

English Level: R2

Energy Efficiency of Industrial Furnaces

Course Description:

Low/High Temperature Furnaces, Types and BasicFeatures of Industrial Furnaces; Governing Processes in Furnaces (Fuels and Combustion, Furnace and Burner Aerodynamics, Heat Transfer); Effect of Operating Conditions (Excess Air, Pressure Control, Oxygen Enrichment, Combustion Air Preheat, Load Temperature, Temperature and Emissivity of the Flame, WallEmissivity) on the Combustion efficiency, Furnace efficiency, Heating efficiency and Operating cost; Fuel choice, Burner choice, Refractory/Lining construction; Heat recovery and Combustion air preheating equipments; Furnace Control Systems (Air/Fuel Ratio, Temperature, Pressure, Flue gas analysis); Advanced Technologies (Oxygen Enrichment of Combustion Systems, Low NOx firing – Flame less combustion, Ceramic Immersion Tube Burners for Metal Melting, Ceramic Fibre Linings, High Emissivity Wall Coatings, Intelligent controls – Artificial Intelligence); Emissions and pollution control (Emissions Legislation, Formation of NOx, NOx Reduction Techniques). The objective of the course is to provide advanced knowledge in order to achieve the high erenergy efficiency by modern fossil-fuel-firing techniques and to limit the volume of fully combusted gases as well as pollutant emissions discharged in to the atmosphere.

Lecturers: Prof. Ladislav Lazić

Literature:

1. P. Mullinger, B. Jenkins, IndustrialandProcessFurnaces; First edition, Elsevier,2008.
2. W. Trinks et al., Industrialfurnaces, Sixthedition, JohnWiley&SonsInc., NewJersey, 2004.
3. C.E. Baukal, Heat transfer inindustrialcombustion, CRC press LLC, Boca Raton,2000.

ISVU Number: 156061

ECTS Credits: 6

Semester: summer/winter

English Level: R2

Environmental Emissions from the Iron and Steel Metallurgy

Course Description:

Students will be introduced to the Industrial Emission Directive 2010/75 / EU and to the reference documents (BREF) relating to metallurgical processes, which are part of a series of documents of best European and World practice. They will gain knowledge about the overall effects that the metallurgical industry has on the environment.

The acquired knowledge will be used in comparing the state of existing and / or future processes with the prescribed requirements of the directive and in making decisions and giving proposals for the necessary improvement by introducing best available techniques (BAT). In this way, in each metallurgical process, complete environmental protection is achieved, which ultimately ensures getting the so-called environmental permit.

Lecturers: Assoc. Prof. Ivan Brnardić

Literature:

1. Directive 2010/75/EU oft he European Parliament and oft he Council, Official Journal of the EU, L 334, 17.12. 2010.
2. R. Remus, M. A. Aguado-Monsonet, S. Roudier, L. Delgado Sancho, JRC Reference Report, BAT Reference Document for Iron and Steel Production, Industrial Emissions Directive 2010/75/EU, EUR 25521 EN, European Integrated Pollution Prevention and Control Bureau, Seville, Spain, 2013.
3. EUROPEAN COMMISSION, Integrated Pollution Prevention and Control Reference Document on Best Available Techniques in the Smitheries and Foundries Industry, May 2005.

ISVU Number: 156069

ECTS Credits: 6

Semester: summer/winter

English Level: R2

Innovative Processes of Metal Casting

Course Description:

Demands and expectations by industry as intensive user of castings placed in front of foundries.

Casting processes and tolerances. Near net shape casting concept. Integrated approach to the production of metal castings. Simultaneous engineering concept. Casting quality improvement. Increasing the foundry competitiveness through technological development: tendencies to technology of melting and casting development.

Construction Castings: optimization of cast components by finite element method (FEM)and computer aided design (CAD).

Optimization of the casting process: elimination of "trial and error" method, application of computer modeling in order to optimize the casting process, optimal casting pouring and gating system calculation.

The concept of virtual manufacturing of castings. Rapid prototyping: Fused deposition modeling (FDM)process, Selective laser sintering (SLS)process, Stereolithography (SLA) process, Direct Shell Production Casting (DSPC)process, etc.

Modern technologies of casting: Replicast process, low pressure casting in sand moulds, Cosworth process, FM process CLA (Counter gravity process) process.

Pouring system flow and high pressure die casting process characteristics. Direct and indirect"squeeze" process, semi-solid process of casting –Rheocasting and Thixocasting process.

Course objectives: The adoption of innovative concepts for castings designing. Understanding the relationship between process parameters, the quality of the melt, casting and solidification conditions in the microstructure and performance characteristics of castings. Application of tools for virtual manufacturing castings and / or optimization of design of castings.

Lecturers: Assoc. Prof. Zdenka Zovko Brodarac, Prof. Primož Mrvar, Prof. Zoran Glavaš

Literature:

1. H. Kaufmann, P. J. Uggowitzer, Metallurgy and Processing of High – Integrity Light Metal Pressure Castings, Schiele&Schön GmbH, Berlin, 2007.
2. A.de Figueredo, Science and Technology of Semi-Solid Metal Processing", North American Diecasting Association, Rosemont, ILL, 2001.
3. Metals Handbook, Volume 15, Casting, ASM International, Metals Park Ohio, 2008.

ISVU Number: 156077

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Leaching Processes in Hydrometalurgy

Course Description:

The aim of the course is to acquire the knowledge necessary to manage hydrometallurgical leaching processes. Hydrometallurgical leaching processes are carried out by acid, alkali and salt water solutions. Leaching methods are: in place, dump leaching, vat leaching and pulp leaching.

Lecturer: Prof. Damir Hršak

Literature:

1. F. Habashi, Metals from Ores, Métallurgie Extractive Québec, Sainte-Foy, 2003.
2. D. Hršak, Hidrometalurgija, Metalurški fakultet Sveučilišta u Zagrebu, Sisak, 2008.
3. C. K. Gupta, Chemical Metallurgy, Wiley – VCH Verlag GmbH & Co. KgaA, Wenheim, 2003.

ISVU Number: 156066

ECTS Credits: 6

Semester: summer/winter

English Level: R2

Mathematical Modelling of Industrial Furnaces

Course Description:

Uses and benefits of modelling. The zone furnace models: Single-gas, One-dimensional, Two- and three-dimensional models. Computational fluid dynamic (CFD) models: Governing equations, Boundary types and Conditions, Computing sub-models (Turbulence models, Reaction models, Radiation models, Wall functions), Solution methods of equations, Model validation.

Application of CFD models: flow simulation in combustion chambers, prediction of furnace heat flux distribution and thermal performances, flame simulation, burner design. Main steps in a formulation of CFD model using a commercial software package: Pre-processing, Solver, Post-processing. The relative advantages and disadvantages of various modeling models. The mathematical modelling of transient thermal conduction in the stock (Transient thermal conduction, Differential equations, Boundary conditions). Application of the finite element technique for modelling irregular 2-D and 3-D geometries in simultaneous transient conduction and thermal stress analysis in the bodies of complex shape. The objective of this course is to describe the methods of application of mathematical modelling techniques to the design and the prediction of thermal performance of directly fossil-fuel-fired industrial furnaces.

Lecturers: Prof. Ladislav Lazić, Asst. Prof. Martina Lovrenić Jugović

Literature:

1. L. Lazić, Numerical methods in thermal analysis, University textbook, ISBN: 978-953-7082-04-8, Sisak, 2007.
2. J.M. Rhine, R.J. Tucker, Modelling of Gas-Fired Furnaces and Boilers, McGraw-Hill Book Company, 1991.
3. P. Mullinger, B. Jenkins, Industrial and Process Furnaces; First edition, Elsevier,2008.

ISVU Number: 156062

ECTS Credits: 6

Semester: summer/winter

English Level: R2

Metallurgy of Aluminum

Course Description:

History and current state in themetallurgy of aluminum and non-ferrous metals. Basic stages in the production of aluminum (obtaining alumina: Bayer's process; electrolytic reduction of alumina; aluminum refining). Calculation of Bayer's plant for obtaining of the alumina. Calculation of plant capacity for obtaining of the aluminum by electrolytic reduction of alumina. Treatment of aluminum and its alloys. Casting of aluminum slabs and billets as semi-finished products. Semicontinuous direct water cooling process (Direct Chill Process, ″DC″). Principles of solidification and structure formation during ″DC″ casting. Microstructural characterization of specific aluminum alloys. Casting parameters in ″DC″ casting. Basic theoretical and practical knowledge in the ″DC″ casting slabs of specific aluminum alloys. Determination of the effect of cooling rate on the properties and homogeneity of cast slabs.

Lecturer: Assoc. Prof. Natalija Dolić

Literature:

1. D. G. Eskin, Physical Metallurgy of Direct Chill Casting of Aluminium Alloys, CRC Press/ Taylor and Francis Group, Boca Raton, 2008.
2. ASM Specialty Handbook®, Aluminum and Aluminum Alloys, ur. J. R. Davis, ASM International, Materials Park, Ohio, 2002.
3. Handbook of Extractive Metallurgy, Volume II: Primary Metals, Secondary Metals, Light Metals, ur. F. Habashi, WILEY-VCH, Weinheim-Chichester-New York – Toronto – Brisbane – Singapore, Germany 1997.

ISVU Number: 156071

ECTS Credits: 6

Semester: summer/winter

English Level: R2

Metallurgy of Cast Irons and Steels

Course Description:

The course studies the following: Classification of cast irons and steels. Solidification of castirons. Metallurgy and properties of graphitic and white casti rons. Reduction of variations in the microstructure of graphitic cast iron castings. Solution strengthening ofductile and compacted graphite iron by silicon. Alloyed ferritic and austeniticgray and ductile irons for elevated -temperature applications. Alloyed ferritic gray iron for corrosion resistance. High-alloyed white cast irons for abrasion-resistant applications, corrosion-resistance applications and high-temperatures applications. Metallurgical quality of the graphitic cast Irons melts. Modern quality control systems of the melt based on thermal analysis and artificial intelligence methods. Solidification of cast steels. Metallurgy and properties of carbon cast steels, low-alloyed cast steels and high-alloyed cast steels for corrosion-resistance applications, high-temperatures applications and abrasion-resistant applications.

Courseobjectives: Introduce students to the metallurgy of cast irons and steels, focusing on specific types of cast irons and steels, and the connection of the melt quality with the microstructure and properties of the castings.

Lecturer: Prof. Zoran Glavaš

Literature:

1. MetalsHandbook, Volume 15, Casting, ASM International, Ohio 2008.
2. CastIron, ASM International, Materials Park, 1999.
3. Steel CastingsHandbook, 6th Edition, editors: N. Blair, T. L. Stevens, ASM International, 1995.

ISVU Number: 156075

ECTS Credits: 6

Semester: summer/winter

English Level: R0

Modern Methods of Chemical Analysis in Metallurgy

Course Description:

The aim of the course is to introduce of students with modern methods of chemical analysis and its application in the analysis of metallurgical samples. Preparation of samples for metallurgical analysis, atomic absorption spectrometry, atomic emission spectrometry, infrared spectroscopy, Raman spectroscopy, X-ray spectroscopy,mass spectrometry, automated methods of analysis.

Lecturer: Assoc. Prof. Anita Štrkalj

Literature:

1. D. Harvey, Modern Analytical Chemistry, The McGraw-Hill Companies, Boston, 2000.
2. F. A. Seetle, Handbook of Instrumental Techniques for Analytical Chemistry, Prentice-Hall, Inc. New Jersy, 1997.

ISVU Number: 156074

ECTS Credits: 6

Semester: summer/winter

English Level: R0

Phase Transformations in Metallic Materials

Course Description:

Phase diagrams. Predicting of thermodynamic parameters. Thermodynamic modeling by Thermo-Calc. Diffusion and diffusion less phase transformations. Thermodynamics of interfaces. Grain-boundary segregation. Grain growth. Phase transformations of ordering. Nucleation. Precipitation. Nonequilibrium transition phases. Recrystallization. Thermodynamics of microstructure change. Reaction kinetics. Kinetics of transformation in solid state. Experimental determination of thermodynamic and kinetic parameters. Martensitic transformations. Phase transformations in steel and light metals.

Objectives: understanding of the thermodynamic forces for phase transformations, application of programs and experimental techniques.

Lecturers: Assoc. Prof. Tamara Holjevac Grgurić, Prof. Stjepan Kožuh

Literature:

1. D.M.Herlach, Phase Transformations in Multicomponent Melts, Wiley-VCH Verlag GmbH, Weinheim, 2008.
2. J.W. Christian, The Theory of Transformations in Metals and Alloys, Elsevier Science Ltd., Oxford, 2002.
3. Robert deHoff, Thermodynamics in Materials Science, Taylor & Francis Group, New York, 2006.

ISVU Number: 156073

ECTS Credits: 6

Semester: summer/winter

English Level: R2

Special Alloys

Course Description:

Basic types of shape memory alloys (Ni-Ti, Cu-Al-Ni, Cu-Al-Znetc.). Diagrams of these alloys. Martensite transformation mechanism. Thermomechanical behavior. Metallurgical technologies for production of shape memory alloys (rapid solidification, classical casting, continuous casting, powder metallurgy, etc.). Processing of these alloys in the semi-products. Biomaterials. Biomedica lalloys of titanium. Dental alloys. Superalloys. Metallic glasses. Mechanical and corrosion properties of individual alloys. Application of special alloys. Effect o fcomposition on the microstructure. The main objectives of the course are to introduce some special alloys, metallurgical technologies for production and processing these alloys, especially shape memory alloys and biomedical alloys.

Lecturers: Prof. Mirko Gojić, Assoc. Prof. Ljerka Slokar Benić

Literature:

1. K. Otsuka, C. M. Wayman, Shape memory alloys, Cambridge University Press, Cambridge, 1998.
2. K. Otsuka X. Ren, Physica lMetallurgy of Ti-Ni Based Shape Memory Alloys,Progress in Materials Science 50 (2005) 511-678.
3. D. F. Williams, The Biomaterials, Elsevier Ltd., Oxford, 2006.

ISVU Number: 156072

ECTS Credits: 6

Semester: summer/winter

English Level: R2

Theory of Metallurgical Processes

Course Description:

Equilibrium. Thermodynamic potentials. Liquid and solid solutions. Equilibrium diagrams of state. Thermodynamics of defects. Surface energy. Thermodynamics of difussion. Thermodynamics and kinetics of nucleation and growth. Nucleation models. Solid state reaction kinetics, definition of reaction range. Kinetic models: diffusion, phase boundary reactions, nucleation and growth. Nonisothermal conditions. Thermodynamics and process kinetics: compound stability, oxidation and reduction. Subcooling. Equilibrium of the local boundary surfaces. Morphological instabilities: reaction instability fronts, dendritic solidification, eutectic solidification. Chemical and physical properties of slag, phase diagrams of slag, structure of metallic and non-metallic systems in the molten state, kinetics of vacuum processes.

Course objectives are the adoption of theoretical knowledge related to the thermodynamics of current and solid state, adoption of thermodynamic concepts of phase equilibrium, understanding and interpretation of equilibrium state diagrams, understanding the kinetics of reactions in solid condition.

Lecturer: Prof. Jožef Medved

Literature:

1. D. R. Gaskell, Introduction to the thermodynamics of Materials, Taylor & Francis, New York, 2008
2. T. Nishizawa, Thermodynamics of microstructures, ASM International®, Materials Park, Ohio, USA, 2008
3. M. J., Pilling, P.W.Seakins,. Reaction Kinetics, Oxford University press, 1995

ISVU Number: 156079

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Wastes and By-products of the Metallurgical Industry

Course Description:

Students will be introduced to waste management and / or by-products as a set of activities aimed at preventing the generation of metallurgical waste and / or by-products, reducing the generated quantities and possible harmful effects on the environment. They will be introduced to a systematic approach to industrial metallurgical waste and / or by-products, their importance in environmental protection, state-level regulations, norms, EU directives, principles on which waste management is based, protection of all environmental components from uncontrolled waste disposal and possible harmful effects of metallurgical waste as well as the possibilities of its use in metallurgical or other industrial processes.

Lecturer: Assoc. Prof. Ivan Brnardić

Literature:

1. S. R. Rao, Resource recovery and recycling from metallurgical wastes, Elsevier,Oxford, England, 2006.
2. Nelson Leonard Nemerow, Industrial Waste Treatment – Contemporary Practiceand Vision for the Future, Elsevier Science & Technology Books, Oxford, UK, 2006.

ISVU Number: 156070

ECTS Credits: 6

Semester: summer/winter

English Level: R2

Welding Metallurgy

Course Description:

Weldability. Metallurgical reactions during welding (dissolving of gases, refining, deoxidation, alloying). Characterization methods of weldability.Melting of metal and formation of welded joints.Influence of alloying elements on weldability. Weld metal. Heat affectedzone. Development of microstructure in welded joint. Second phaseparticles and precipitates in weld metal. Specificity of welding of alloysbased on ferrous and non-ferrous metals. Pre-heating and heat treatment ofwelded joint.Failures of welded joint. Mechanical and corrosion properties of welded joint.

Main objectives of the course are: learning to the basic physical and chemical processes during welding, andexploring the behavior of different materials during welding.

Lecturers: Prof. Mirko Gojić, Prof. Stjepan Kožuh

Literature:

1. M. Gojić, Tehnike spajanja i razdvajanja materijala, Metalurški fakultet Sveučilište u Zagrebu, II. nepromijenjeno izdanje, Sisak, 2008.
2. G. Medeni, A. Pavelić, Osnove zavarivanja, Tehnički fakultet Sveučilišta u Rijeci, Rijeka, 2000.
3. J.C. Lippold, D.J. Kotecki, Welding and Weldability of Stainless Steels, John Wiley&Sons, Inc. Publication, New Jersey, 2005.

ISVU Number: 156065

ECTS Credits: 6

Semester: summer/winter

English Level: R1

Study module:

Naval Architecture and Ocean Engineering

List of fundamental elective courses of the doctoral study module:

1. Continuum Mechanics
2. Equations of Mathematical Physics
3. Mathematical Methods in Marine Hydrodynamics
4. Numerical Linear Algebra

List of elective courses of the doctoral study module:

1. Advanced Methods for Ship Structure Modelling and Analysis
2. Advanced Methods of Fatigue Assessment of Welded Ship Structures
3. CFD in Ship Design
4. Design of Marine Propulsion Systems
5. Effects of In-Built Material Properties on As-Built Ship
6. Feasibility and Reliability in Structural Design
7. Hidroelasticity of Ships and Marine Structures
8. Multi-Criteria Models for Ship Concept Design
9. Multi-Criteria Optimization of Thin-Walled Structures
10. Offshore Structure Loading
11. Probabilistic Approach to Damaged Stability
12. Profitable Ship Design
13. Ship Propulsion System Vibrations
14. Shipbuilding Management
15. Shipbuilding Production Process Methods and Systems
16. Ships Collision and Grounding
17. Simulation and Analytical Methods in Reliability of Marine Objects
18. Stochastic Modelling of Loads of Ship Structures
19. Structural Safety
20. Theory of Seakeeping and Maneuverability

Continuum Mechanics

Course Description:

Introduction to Vectors and Tensors. Curvilinear Coordinates. Kinematics. Concept of Stress. Balance Principles. Objectivity. Linear elastic behaviour. Hyperelasticity. Fundamental of Continuum Plasticity. The Flow Theory of Plasticity. Flow Rule, Yield Criterion, Strain Hardening, Loading – Unloading Conditions. Finite Deformations in Plasticity. Viscoelasticity – linear and nonlinear models.

Lecturers: Prof. Emer. Ivo Alfirević, Assoc. Prof. Igor Karšaj

Literature:

1. Alfirević, I.: Uvod u tenzore i mehaniku kontinuuma, Golden Marketing, Zagreb, 2003.
2. Holzapfel, GA: Nonlinear Solid Mechanics – A Continuum Approach for Engineering, Wiley, 2000
3. Alfirevic, I: Tenzorski račun i tenzorska mehanika, Golden Marketing, Zagreb, 2006.

ISVU Number: 155493

ECTS Credits: 6

Semester: winter

English Level: R3

Equations of Mathematical Physics

Course Description:

Familiarize students with the basic mathematical theory of boundary value problems for partial differential equations in one or more dimensions.

Lecturer: Prof. Luka Grubišić

Literature:

1. I. Aganović, K. Veselić, Linearne diferencijalne jednadžbe. Uvod u rubne probleme, skripta PMF – Matematičkog odjela, Zagreb, 1992.
2. M. R. Spiegel, Fourier analysis with applications to boundary value problems, Schaum'e, McGraw – Hill, 1974.
3. I. Aganović, K. Veselić, Jednadžbe matematičke fizike, Školska knjiga, Zagreb, 1985.

ISVU Number: 155494

ECTS Credits: 6

Semester: winter

English level: R3

Mathematical Methods in Marine Hydrodynamics

Course Description:

Review of fluid dynamics models and boundary conditions on the free surface in marine hydrodynamics (Navier-Stokes equations, Reynolds equations, boundary layer theory, potential flow models). Review of discretization methods based on grid (finite difference method, finite volume method, finite element method and panel method) as well as meshless methods; and theoretical basics for numerical methods: consistency, stability, convergence and accuracy. Methods for solving viscous fluid flow with and without free surface (grid generation, treatment of nonlinearity, generation of smoothing functions). Methods for solving inviscid potential flow with free surface.

Lecturers: Prof. Nastia Degiuli, PhD Šime Malenica

Literature:

1. Ohkusu, M.:Advances in Marine Hydrodynamics, Computational Mechanics Publications, Southampton, 1996.
2. Kostjukov,A.,A.: Teorija karabelnych voln i volnovogo soprotivlenija, Sudpromgiz, Leningrad. 1959.
3. Faltinsen, O., M.: Sea loads on ship and off-shore structure, Cambridge University Press, 1993.
4. Hirsch, C.: Numerical Computation of Internal and External Flows, Vol.I and II, John Wiley & Sons, New York, 1992.
5. Katz, J., Plotkin, A.:Low-Speed Aerodynamics-From Wing Theory to Panel Methods, McGrawn-Hill, Inc., 1991.
6. Liu, G. R., Liu, M. B.:Smoothed Particle Hydrodynamics, World Scientific Publishing Co. Pte. Ltd.,2003.

ISVU Number: 156128

ECTS Credits: 6

Semester: winter

English Level: R3

Numerical Linear Algebra

Course Description:

To understand concepts of the numerical linear algebra and scientific computing with emphasys how to choose a method for solution of the problem and the possible numerical errors in obtained results. Learn how to use the numerical libraries for solution of subproblems.

Lecturer: Prof. Sanja Singer

Literature:

1. James W. Demmel, Applied Numerical Linear Algebra, SIAM, 1997.
2. Lloyd N. Trefethen and David Bau, III, Numerical Linear Algebra, SIAM 1997.

ISVU Number: 155491

ECTS Credits: 6

Semester: winter

English Level: R2

Advanced Methods for Ship Structures Modelling and Analysis

Course Description:

Course presents advanced state-of-the-art methods of modelling and analysis of ships structures through the following topics:

Finite element method, different formulations, special elements, macroelements, superelemenets and submodels. Modelling of ship structures for calculation of motions, wave loads and strength.

Structural analysis (methods and methodology) of contemporary types of ships: container ships, LPG carriers, asphalt carriers, cruise ship, car carriers, Ro-Ro, Ro-Pax, mega yachts, catamarans. Safety factors. Classification society Rules and recommendations.

Feasibility criteria, buckling calculation, bifurcation analysis, non-linear analysis (geometrical and material), ultimate strength of stiffened panels and hull girder. Structural detail and stress concentrations calculations.

Fatigue strength of ship structures. Fatigue loads and stress calculation. Elastic-plastic analysis. Cyclic loading and stress distribution. Fatigue life calculation. Classification society Rules and recommendations. S-N curves, crack mechanics, safety factors.

Shell theory. Rotation and general shell. Differential equation. Analytical solution. Matrix methods. Strength and stability calculation of shells. Structural analysis of submarines.

Lecturers: Assoc. Prof. Jerolim Andrić, Prof. Smiljko Rudan

Literature:

1. Hughes, O.F., Paik, J.K. Ship structural analysis and design. The Society of Naval Architects and Marine Engineers, 2010.
2. O.C. Zienkiewicz, R.L. Taylor: The Finite Element Method, Mc Graw-Hill Book Company, Volume 1 and 2, 1994/1991.
3. M.A.Crisfield: Non-linear Finite Element Analysis of Solids and Structures, John Willey&Sons, 1998.
4. I. Senjanović: Metoda konačnih elemenata u analizi brodskih konstrukcija, Sveučilište u Zagrebu, FSB, Zagreb, 1998.
5. I. Senjanović: Theory of Shells of Revolution, Brodarski institut, Zagreb, 1972.
6. W. Fricke, H. Petershagen: Fatique Strength of Ship Structures, Part I and II, Germanischer Lloyd, Hamburg, 1997/98.

ISVU Number: 156130

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Advanced Methods of Fatigue Assessment of Welded Ship Structures

Course Description:

The present course provides an overview of advanced methods for fatigue analysis including the crack propagation methods. Furthermore, corrosion prediction models and ship hull degradation models are described. Uncertainties in all pertinant variables are covered, including: uncertainties in fatigue loading, uncertainties in fatigue stresses and uncertainties in fatigue life assessment. Fatigue reliability methods are studied. Consequencies of fatigue cracks on ship structural safety are analysed. Methods for hull inspection, crack detection and measurement of corrosion degradation are compared. Finally, practical applicability of fatigue reliability theory for rational inspection planning are also covered by this course.

Lecturer: Prof. Joško Parunov

Literature:

1. Almar-Naess, A., 1985. Fatigue Handbook, Offshore Steel Structures. Tapir.
2. Lassen, T., Recko, N., 2006. Fatigue Life Analysis of Welded Structure. ISTE
3. Niemi, E., Fricke, W. and Maddox, S.J., Structural Hot-spot Stress Approach to Fatigue Analysis of Welded Components, IIW document XIII-1819-00, 2004.
4. A. Hobbacher, Recommendation for Fatigue Design of Welded Joints and Components, IIW document XIII-1539-96 / XV-845-96
5. DnV, 2010. Fatigue Assessment of Ship Structures, Classification Notes No 30.7.

ISVU Number: 156116

ECTS Credits: 6

Semester: summer/winter

English Level: R3

CFD in Ship Design

Course Description:

Fundamental (hydromechanic) characteristics of ship: buoyancy, stability, speed, controllability, seakeeping. A model as a classical way to determine the ship hull form characteristics. Limitations of a classical approach in selection, modifications and optimization of ship hull form during the ship design stage. Application of CFD tools for evaluation of ship hull form. Mathematical models and numerical methods. Basic equations and boundary conditions. Discretization of domain and generation of computational grids. Potential flow past a ship hull form. Free-surface models. Linearised and non-linear models. Viscous flow past a ship hull form. Turbulence models. Visualization of results. Verification and validation of numerical models. Procedure for application of CFD tools to the various stages of ship design. Optimization for required characteristics of ship hull form using CFD tools. Contemporary CFD software packages.

Lecturers: Prof. Nastia Degiuli, Prof. Roko Dejhalla

Literature:

1. Bertram, V., Practical Ship Hydrodynamics, Butterworth Heinemann, Oxford, 2000.
2. Raven, H., A Solution Method for the Nonlinear Ship Wave Resistance Problem, Ph.D. Thesis, TU Delft, 1996.
3. Janson, C.E., Potential Flow Panel Methods for the Calculation of Free Surface Flows with Lift, Ph.D. Thesis, Chalmers University of Technology, 1996.
4. Ferziger, J.H., Peric, M., Computational Methods for Fluid Dynamics, Springer Verlag, 2001.

ISVU Number: 156134

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Design of Marine Propulsion Systems

Course Description:

Introduction in advanced energy efficient marine propulsion systems. Introduction in innovative energy efficient and environmentally friendly production of different forms of energy required in ship. Studying of different approaches in methodology of design of marine propulsion systems with emphasis on ships type and purpose. Introduction in methodology of design of integrated marine energy systems.

Lecturer: Asst. Prof. Nikola Vladimir

Literature:

1. H.K.Woud; D. Stapersma : Design of Propulsion and Electric Power Generation Systems, London, UK, 2003.
2. R.L. Harrigton : Marine Engineering, SNAME, USA, 1992.
3. H.D.Baehr; K.Stephan: Heat and Mass Transfer, Springer Verlag, Heidelberg, 1998.

ISVU Number: 156202

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Effects of In-built Material Properties on As-built Ships

Course Description:

In the introductory consideration the material flow and appropriate places for specimen selections will be considered. Tensile testing, fatigue testing and Charpy testing for determination of impact energy of shipbuilding steels will be performed in the laboratory on the specimens collected in shipyards. Specific standards for material testing based on rules and regulations of classification societies will be applied. Specimen preparation will be considered in order not to affect the mechanical properties of materials. Statistical methods including sample theory will be included. In the continuation the importance of differentiation between the design and in-built material properties in rules of classification societies will be clarified. The effects of in-built material properties on local and global strength of plating and stiffening, of stiffened panels and girders as well as of the whole hull girder with respect to bending and buckling under lateral, axial and in-plane loads in elastic and plastic region on normal and low temperatures will bi considered in details. Particular attention will be focused to the strength of welded joint and deposited materials with respect to the base material. The effects of in-built materials on the ultimate strength of the ship hull will be analytical investigated by numerical iterative-incremental method.

Lecturers: Prof. Emer. Kalman Žiha, Asst. Prof. Zvonimir Tomičević

Literature:

1. IACS International Association of Classification Societies: Common Structural Rules for Bulk Carriers, Ch. 3 Materials, Ch. 5 Hull girder strength, Ch 6 Hull scantlings, 2008, www.iacs.org .
2. Croatian Register of Shipping (CRS): Part 1-General Requirements, Part 2-Hull, Part 25 Metalic Materials, Part 26-Welding, Split, Croatia, 2011.
3. Bureau Veritas (2003): MARS 2000, Paris, 2003.
4. Radaj D., Vormwald M., Ermüdungsfestigkeit. Springer, 2007. 5. Lemaitre J., Desmorat R., Engineering Damage Mechanics Ductile, Creep, Fatigue and Brittle Failures. Springer, 2005.
5. Lemaitre J., Desmorat R., Engineering Damage Mechanics Ductile, Creep, Fatigue and Brittle Failures. Springer, 2005.

ISVU Number: 156085

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Feasibility and Reliability in Structural Design

Course Description:

Design oriented analytical and numerical calculation methods for structural response. Integral (weak) formulation of elasticity problem. Variational and modified variational principles. Mixed and hybrid finite element formulations. Special finite elements, macroelements, superelements convenient for structural adequacy and reliability analysis. Theory of post-critical structural behaviour and local buckling. Numerical solution strategies. Dynamic stability of non-conservative systems. Classification of instability problems and inclusion of time. Energy theorems. General theory of elastic bifurcation. (Option: One-dimensional and bimodal catastrophes). Global and local longitudinal and shear ultimate load-capacity. Incremental-iterative progressive collapse analysis method. NLFEM in analysis of global and local ultimate load-capacity. Effect of initial imperfections on load-capacity. Design loads and combinations of loads and responses. Structural safety measures (deterministic and stochastic formulations). Automatic safety margin generation. Beta-method on mechanism level. Optimal design by Beta-method. Robustness and reliability as objectives (and constraints) in design procedure.

Lecturer: Assoc. Prof. Jerolim Andrić

Literature:

1. Hughes, O.F., Paik, J.K. Ship structural analysis and design. The Society of Naval Architects and Marine Engineers, 2010.
2. Paik, J.K., Thayamballi, A.K. Ultimate limit state design of steel-plated structures, Wiley, Chichester 2003.
3. Augusti, G., Barata, A., Casciati, F., Probabilistic Methods in Structural Engineering, Chapman and Hull, 1985.
4. Ditlevsen, O., Madsen, H.O.: Structural Reliability Methods, Wiley 1996.
5. Clough, R., Penzien, J.: Dynamics of Structures, McGraw-Hill, 2001

ISVU Number: 156217

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Hydroelasticity of Ships and Marine Structures

Course Description:

Development and overview of hydroelastic analysis models (linear, nonlinear, frequency and time domain). Springing and whipping of ship structures due to harmonic and impulsive wave loading. Global and local hydroelastic response. Floating body dynamic equation of motion. Structural model (1D, 3D), hydrodynamic model (integral formulation of hydroelastic boundary value problem, Rankin and Kelvin Green function, collocation method-panel method, forward speed problem), hydrostatic model (basics of restoring stiffness formulation). General formulation of finite and boundary element problem in shipbuilding. Solution of the dynamic equation in frequency domain (modal approach). Numerical methods for integration of the dynamic equation in time domain (Runge-Kutta, Hubolt, Wilson θ, Newmark, Harmonic acceleration method). Application of hydroelastic models for analysis of ultra large container ships (ULCS), tension leg platforms (TLP), very large floating structures (VLFS), LNG ships, hydroelasticity of risers. Classical seakeeping vs. hydroelasticity.

Lecturers: Prof. Emer. Ivo Senjanović, PhD Šime Malenica

Literature:

1. R.E.D. Bishop, W.G. Price: Hydroelasticity of Ships, Cambridge University Press, 1979.
2. C.M. Wang, E. Watanabe, T. Utsunomiya: Very Large Floating Structures, Taylor & Francis, 2008.
3. S.M. Han, H. Benaroya: Nonlinear and Stochastic Dynamics of Compliant Offshore Structures, Kluwer Academic Publishers, 2002.
4. P. Bar-Avi, H. Benaroya: Nonlinear Dynamics of Compliant Offshore Structures, Swets & Zeitlinger Publishers, 1997.
5. O.M. Faltinsen, A.N. Timokha: Sloshing, Cambridge University Press, 2009.

ISVU Number: 156190

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Multi-Criteria Models for Ship Concept Design

Note: course not offered in 2020-2021 academic year.

Course Description:

Ship design as a decision-making process, Decision-making by multi-criteria concept design parametric model. Pareto frontier (hyper-surface of non-dominated designs), visualization of the multi-dimensional space, objective and subjective measure of merit, sensitivity and robustness of the design solution, Parameters and attributes of the design problem. Parametric model of the ship at the concept design level, principles of abstraction and reduction, selection of parameters and attributes, selection of variables and constraints, solving equality constraints, measure of merit, handling uncertainty and setting margins to critical attributes, design balance. Defining operational scenario, formulation of parametric modules dealing with hull form, buoyancy, stability, damage, mass, space, resistance, propulsion, powering, sea keeping, manoeuvrability, strength, vibration, cost, operation expenses, required freight rate, etc. Examples of parametric models. Special modules for interface to the higher level of design (hull form generating, basic specification, basic general arrangement plan).

Literature:

1. F. Mistree, et al., Decision based design, a contemporary paradigm for ship design, Trans. SNAME, Vol 98, 1990. pp 565-597.
2. H. Nowacki, Simulation of discreete stochactic systems for ship design and operation, 21″ WEGEMT, 1994.
3. I. Grubišić, G. Trincas, V. Žanić, Efficient Solution of the Multiattribute Design Problem applied to Fast Passenger Vessels, II Symposium on ″High Speed Marine Vehicles″, Vol.II, Naples, 1993, pp. 323-336
4. I. Grubišić, V. Žanić, G. Trincas, Sensitivity of Multiattribute Design to Economy Environment: Shortsea Ro-Ro Vessels, Proceedings of the 6″th International Marine Design Conference, IMDC″97, Newcastle upon Tyne, 1997, pp. 201-216.
5. OPTIMISTIC – Optimization in Marine Design, 39th WEGEMT School for practicing engineers and post-graduates in the marine industry, Lothar Birk and Stefan Harries (Editors), 2003.
6. I. Grubisic, E. Begovic: ″Multi-Attribute Concept Design Model of Patrol, Rescue and Antiterrorist Craft″, 7th International Conference on FAST Sea Transportation, FAST 2003, Ischia 7-10 Oct. 2003, Vol 3, D1, pp. 91-98.

ISVU Number: 156194

ECTS Credits: 6

Semester: summer/winter

English Level: R0

Multi-Criteria Optimization of Thin-Walled Structures

Course Description:

Design support problem basics. Decision support problem identification and formulation. Design space and attribute space. Formulation of the ship or ship structure mathematical modules for the decision-making system. Design mapping vs. evaluation mapping. Multi-attribute versus multi-objective approaches/techniques for decision making. Formulation of realistic analysis module (response, feasibility) applicable in the synthesis procedures. Formulation of realistic synthesis module (objective and subjective decision making). Hierarchy of design procedures. Conceptual and preliminary design. Decomposition of structure on substructures. Formulation of the design model – analytical and synthetic module for both level of design and for all substructures. Concept of non-dominance for filtering the efficient solutions (Pareto frontier). Problem manipulations and solution strategies (SLP, evolution strategies, FFE, MOGA, MOPSO). Inter and intra attribute preferences. Attribute normalisation using fuzzy functions. Determination of consistent relative importance of attributes. Designer's heuristic preferences regarding multiple attributes and selection among efficient solutions using Lp-norms. Interactive selection of preferred design with selection of the attribute weights, distance norms, targets, membership grade, etc. Robustness attributes. Visualisation. Decision support problem in the concept design – systems OCTOPUS and MAESTRO. Applications to the ship general and ship structural design in practical design environment.

Lecturers: Assoc. Prof. Pero Prebeg, Assoc. Prof. Jerolim Andrić

Literature:

1. Hughes, O.F., Paik, J.K. Ship structural analysis and design. The Society of Naval Architects and Marine Engineers, 2010.
2. Yu, Po-Lung , 1985, 'Multiple Criteria Decision Making', Plenum Press, New York.
3. Montgomery, D. C. (1991, 2001) Design and Analysis of Experiments, Third Edition, John Wiley and Sons Ltd.
4. Papanikolau, A. (ed.), 2009, Risk-Based Design-Methods, Tools, Applications, Springer-Verlag.
5. Taguchi, G. (1986): Introduction to Quality Engineering, Dearborn, MI: Asian Productivity Organization (distributed by American Supplier Institute Inc.).

ISVU Number: 156209

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Offshore Structure Loading

Course Description:

Hydrodynamic loading on fix and mobile offshore structures due to waves and sea current. Application of the Green's function and Green's theorem in explanation of the diffraction and radiation phenomena. Velocity potential in incoming, diffracted and radiated waves. Hydrodynamic pressure in waves. The 2nd order hydrodynamic wave forces– mean value and slow varying. The Morison equation. Viscous effects and dumping. Nonlinear theory of steep waves. Numerical methods in the analysis of waves – in frequency domain and time domain. Advantages and disadvantages of different methods. Multi-physical models in fluid-structure interactions – pertaining analytical and numerical methods. Software applications. Illustrative examples from the contemporary praxis in offshore engineering: jacket structures in waves, self-elevating (jack-up) platforms, semisubmersibles, offshore wind turbine structures.

Lecturer: Asst. Prof. Ivan Ćatipović

Literature:

1. J. Prpić-Oršić,V. Čorić: Pomorstvenost plovnih objekata; UDK 629.5.017(075.8); Zigo, Rijeka 2006.
2. J.M.J. journée; W.W. Massie: Offshore Hydromechanic; Delft University of Technology; 2001
3. Faltinsen, O.M.: Sea Loads on Ships and Offshore Structures; Cambridge University Press; 1998
4. Chakrabarti, S.K.: Hydrodynamics of Offshore Structures; WIT Press, Sothempton; 2001
5. Sarpakya, T.; Isaacson, M.: Mechanics of Waves Forces on Offshore Structures; Van Nostrand Reinhold Co.; New York; 1981

ISVU Number: 156203

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Probabilistic Approach to Damage Stability

Course Description:

The course will start with a general description of the development of ship damage stability standards, taking especially in consideration relevant accidents and the identification of weak points in the deterministic standards. A comprehensive description of the theoretical foundations of the probabilistic method, in general, will then be provided. This will be followed by an overview of the existing regulations (Resolution . A.265[VIII], MSC.19(58)) based on the probabilistic method, with special emphasis on the differences between different regulations. The new harmonized probabilistic regulations will also be reviewed. These methods will be applied through case studies, aiming to highlight some common difficulties found in its application.

Lecturer: Assoc. Prof. Vedran Slapničar

Literature:

1. International Convention for the Safety of Life at Sea (SOLAS), 2009 Consolidated Ed.
2. Santos T.A. & Guedes Soares, C. Probabilistic approach to damage stability in: Advanced Ship Design for Pollution Prevention, ed. Guedes Soares & Parunov, Taylor & Francis Group, London, UK, 2010. p.227-242.
3. Contemporary Ideas on Ship Stability, Elsevier, ISBN 0 08 043652 8, December 2000, 597pp., edited by D. Vassalos, M. Hamamoto, A. Papanikolaou and D. Molyneux.

ISVU Number: 156212

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Profitable Ship Design

Course Description:

Feasible region of design requirements. Constraints: technical, economic and administrative. Target function as the minimum cost of construction and profitability of the vessel service. Market as a generator weight factors of target function. Complementarity of design parameters with the technological process of the shipyard. Forecast of commodity and financial markets. Ship cost model as function of the ship parameters. Ship design process for optimum shipbuilding. Model of service profitability. The essential elements of the model: input freight rate, labor cost, fuel cost, capital cost, maintenance and administrative costs. Forecast profitability for given routes. Scheduled maintenance. Fleet selection.. Elements of financial mathematics. Money in the function of time. Reduced to the net present value and the final value. Investment programs. Marginal interest. Legal regulations.

Lecturer: Assoc. Prof. Vedran Slapničar

Literature:

1. Buxton, I.L., Engineering Economics and Ship Design, British Maritime Technology, 1987.
2. Erichsen, S., Management of Marine Design, Butterworths, 1989
3. Benford, H., Principles of Engineering Economy in Ship Design, Butterworks, 1989
4. Benford, H., Ships' Capital Costs, University of Michigen, 1984.
5. Watson, D., Practical Ship Ship Design, Elsevier, 1998.

ISVU Number: 156197

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Ship Propulsion System Vibrations

Course Description:

Introduction in theory of vibrations of linear and nonlinear mechanical systems with application of numerical methods using finite elements. Determination of characteristics of forces in propulsion chain and methods of analyzing and calculating vibrations. Scientific approach in studying atypical vibrations and resonance phenomena in propulsion system from propulsion system and ships hull interaction.

Lecturers: Asst. Prof. Nikola Vladimir

Literature:

1. Vibration Control in Ships, (ISBN: 82 515 0090 7) A.S. VERITEC, Oslo, Norway, 1985.
2. CC.L. Long: Propellers, Shafting and Shafting System Vibration analysis, in: Harrington R.L. (ed.), Marine Engineering, SNAME, New York 1980.
3. E.D. Bently, C.T. Hatch: Fundamentals of Rotating Machinery Diagnostics, ASME Press, New York, 2003.

ISVU Number: 156210

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Shipbuilding Management

Course Description:

Introducing a tasks of shipbuilding preparation process. Introducing a content of production and project management.

Lecturers: Asst. Prof. Neven Hadžić

Literature:

1. Sladoljev, Ž.: Profit Oriented Production Strategy in Shipyards; The Journal of Ship Production, Vol. 12, No. 4, 1996, New Jersey, USA
2. Schroeder, R.G.: Upravljanje proizvodnjom, MATE d.o.o., 1999, Zagreb
3. Ž. Sladoljev: Proizvodna strategija brodogradilišta – interno izdanje, FSB, Zagreb, 1995.
4. PMI – A Guide to the Project Management – Body of Knowledge, Automated Graphic system, 1996, USA

ISVU Number: 156132

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Shipbuilding Production Process Methods and Systems

Course Description:

Introducing to modern shipbuilding production process characteristics, models and systems.

Lecturer: Asst. Prof. Neven Hadžić

Literature:

1. Richard Lee Storch et al.: Ship Production (second edition), SNAME, New Jersey, USA, 1995.
2. Okumoto Y.: Advanced Welding Robot System to Ship Hull Assembly and Approach to Accurate Production of Hull Structures, Journal of Ship Production, Vol. 13, No. 2, New Jersey, USA, 1997.
3. R. Hardison: Accuracy Control – The Keystone of Quality in Shipbuilding, Material Evaluation, January 1998, USA
4. S. Takechi, K. Aoyama, T. Nomoto: Virtual Manufacturing System based on Product Modeling- Developement of Computer- Aided Geometric Accuracy Management System for Steel Structures, Proceedings of The 12 International Offshore and Polar Engineering Conference, Kytakiushu, Japan, 2002.

ISVU Number: 156131

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Ships Collisions and Groundings

Course Description:

Course presents collisions and groundings as a type of marine accident: statistics, cause, risks, consequences. It defines external dynamics and internal mechanics during collision and grounding. Modeling and analytical techniques are presented: theoretical, analytical, experimental and numerical, for both simplified and more accurate calculation methods. An introduction into non-linear finite element method and applicable software is given: modelling technique, contact problem, material models, failure criteria, type and quality of finite element mesh. Calculation examples are presented including the results analysis, as well as comparison to experimental results. Course presents crash-worthy ship structures: optimization, sandwich technology, special structure solutions and technology issues. Other topics: building of protective structures and islands, risk estimation and analysis, rules and regulations, environment protection and consequences, relevant bodies and institutions, analysis of Jadran sea specific problems.

Lecturers: Prof. Smiljko Rudan

Literature:

1. Ted Belytschko, Wing Kam Liu, Brian Moran: Nonlinear Finite Elements for Continua and Structures, Wiley, 2000.
2. Ship Collision Analysis, Eds. Henrik Gluver and Dan Olsen, Balkema, 1998.
3. LS-Dnya, Theory Manual, Livermore Software Technology Corporation, 2006.

ISVU Number: 156136

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Simulation and Analytic Methods in Reliability of Marine Objects

Course Description:

Introduction concerns with the uncertainties of marine structures in operation and with the theoretical fundaments of componential and system reliability. Monte-Carlo simulations will be applied to solutions of complex integrals which cannot be treated otherwise. Particular attention will be devoted to integration of functions of random variables with more or less complex integration domains. It will be demonstrated that some important problems of safety and reliability in ship constructions can be handled by employing integration of complex functions of random variables, and moreover, that the Monte-Carlo simulation is the only feasible method. The methods of random number generations will be considered. Attention will be paid to methods of direct inversion of cumulative distribution functions using common methods such as 'regula falsi', Newton-Raphson and other approximations. Besides the crude Monte-Carlo simulation, which is correct but slow, some accelerating methods, such as exclusion of B-hypo spheres, extreme value distributions, importance sampling, partition of domains, adaptive simulations, stratification methods, Latin-hypercube methods and directional simulations are planned to be studied. Monte-Carlo simulation makes sense only if the convergence conditions are comprehensible; otherwise, experimental convergence checking is needed. Some typical solutions of practical problems in safety and reliability analysis of structures will be elaborated. In system considerations will be considered the possibility of application of the information theory. The analytic methods concern with applications of reliability calculations in definition of loads and responses in the entire operational life time. Practical applications of analytical methods of ship reliability assessments on strength and fatigue problems of marine structures, such as FOSM, FORM, AFORM, will be elaborated according to the rules and regulations of classification societies.

Lecturer: Prof. Emer. Kalman Žiha

Literature:

1. Hammersley, J.M., Handscomb, D.C. Monte Carlo Methods, Methuen, London, 1964.
2. Madsen, H. O., Krenk, S., Lind, N., C., Methods of Structural Safety, Prentice-Hall, New Jersey, 1986.
3. Barlow, R. B., Proschan, F., Mathematical Theory of Reliability, Wiley, NY, 1965.
4. Rao, S. S., Reliability Based Design, McGraw-Hill, NY, 1992.
5. Gnedenko, B., Ushakov, I., Probabilistic Reliability Engineering, Ed. Falk, J., Wiley, NY, 1995.
6. Melchers, R.E. Importance sampling in structural systems, Structural Safety, 6, 1989, pp. 3-10.

ISVU Number: 156086

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Stochastic Modelling of Loads of Ship Structures

Course Description:

Stochastic modelling and extreme values of still water loads. Stochastic model of surface waves. Special types of wave spectra. Short and Long term probabilistic models of waves. Extreme values of waves. Stochastic modelling of wave loads. Short and long term probabilistic models of wave loads. Extreme values of wave loads. Design wave loads. Uncertainty of long-term predictions of wave loads. Stochastic modelling of slamming loads and whipping response. Short and Long term probabilistic models of slamming loads and whipping response. Extreme values of slamming loads and whipping response. Load combinations. Load combinations between still water and wave loads. Load combinations between different components of wave loads. Load combinations between wave loads and whipping loads.

Lecturer: Prof. Joško Parunov

Literature:

1. Hughes O. S., Paik, J.K., Ship structural analyses and design, New Jersey, 2010.
2. Jensen, J.J., Loads and Global Response of Ships, Elsevier 2001.
3. Ochi, M.K., Ocean waves – the stochastic approach, Cambridge 1998.
4. Mansour, A., Liu, D., Strength of Ships and offshore Structures, SNAME, 2008.

ISVU Number: 155463

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Structual Safety

Course Description:

Introduction to structural reliability: structural safety, uncertainties, limits states. Modelling uncertainty and variability. Probabilistic modelling of induced loads and ultimate strength of ship structures. Stochastic load models; load combination. Formulation of structural component reliability: First-order reliability method (FORM); reliability sensitivity measures; the second-order reliability method (SORM). Simulation methods: generation of random numbers; Monte Carlo, importance sampling, and directional simulation methods for structural reliability evaluation. System reliability: classification of systems; review of classical systems reliability methods; bounds on the reliability of series systems; approximate methods for non-series systems. Probabilistic design; codified design formats; partial factor design code format.

Lecturer: Prof. Carlos Guedes Soares

Literature:

1. Ferry Borges, J. and Castanheta, M., 1971, Structural Safety, Laboratório Nacional de Engenharia Civil, 2nd Edition
2. Thoft-Christensen, P. and Baker, M. J., 1982, Structural Reliability Theory and its Applications, Springer-Verlag
3. Melchers, R. E., 1999, Structural Reliability, Analysis and Prediction, 2nd Edition John Wiley & Sons
4. Guedes Soares, C. (Ed.), 1997, Probabilistic Methods for Structural Design, Kluwer Academic Publishers; Dordrecht

ISVU Number: 156059

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Theory of Seakeeping and Manoeuvrability

Course Description:

The dynamics of ships and offshore objects in calm and wave sea. Positioning of the rigid body under stationary hydrodynamic and aerodynamic loading. Hydrostatic stiffness and perturbation of the body static equilibrium position on free surface. Anchoring and positioning of the ships and offshore objects. Dynamics of the body advancing and maneuvering in calm sea: equations of motions, added mass, coefficients of hydrodynamic forces and moments. Influence of appendages. Resistance and propulsion. Control forces and moments (rudders). The dynamics of rigid body in waves. The fundamentals of diffraction and radiation phenomena. Hydrodynamic coefficients in equation of oscillatory motion: hydrodynamic excitation and hydrodynamic reaction (added mass and dumping). Nonlinear phenomena. Strip theory and methods for 3-dimensional models. The solution of equation of motion in frequency and time domain. The consequences of the ship motion in waves: absolute and relative motions, wave loading, added resistance. Definition of the design sea state in short term prediction of the ship response in waves. Maneuvering of ships in waves.

Lecturers: Asst. Prof. Ivan Ćatipović

Literature:

1. J. Prpić-Oršić; V. Čorić: Pomorstvenost plovnih objekata; UDK 629.5.017(075.8); Zigo, Rijeka 2006.
2. Lewandowski, E.M.: The Dynamic of Marine Craft; World Scientific Publishing; London; 2004
3. Faltinsen, O.M.: Sea Loads on Ships and Offshore Structures; Cambridge University Press; 1998

ISVU Number: 155608

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Study module:

Process and Energy Engineering

List of fundamental elective courses of the doctoral study module:

1. Heat and Mass Transfer

List of elective courses of the doctoral study module:

1. Advanced Control for Energy Efficiency and Demand Response in Smart Grids
2. Advanced Quantitative Infrared Thermography
3. Advanced Thermal Measurements
4. Computational Fluid Dynamics
5. Cooling-Heating Processes With Heat Pumps
6. Development of Modern Thermal Power Plants
7. Dynamics and Control of Thermo-Hydraulic Processes
8. Energy and Environmental Protection
9. Energy Planning Methods
10. Evaporative Devices
11. Experimental Methods in Heat and Mass Transfer
12. Measurement and Calibration Systems
13. Methods for Useful Life Estimation of Power Equipments and Machines
14. Metrology of Heat and Process Quantities
15. Modelling and Approximation in Heat and Mass Transfer Processes
16. Modelling of Combustion and Radiative Heat Transfer
17. Numerical Methods in Heat Transfer
18. Numerical Simulations in Energy Conversion Processes
19. Selected Chapters from the Theory of Turbomachines
20. Storage of Thermal Energy in Buildings and Industry
21. The Flow, Thermal and Mechanical Phenomena in Turbomachines
22. Thermal Apparatus and Equipment
23. Transients in Pipelines
24. Wind and Structures

Heat and Mass Transfer

Course Description:

To understand how to formulate mathematical model and boundary conditions for heat and mass transfer problems. To prepare students for the usage of CFD methods. The subject consists from one compulsory and three elective units. Compulsory unit discusses general transport equation, basic lows in integral and differential form, constitutive equations and boundary conditions. Several examples of mathematical models are given.

Elective units are as follows: Unit 1 elaborates temperature distribution in a solid and a detailed analysis of boundary layers. Unit 2 analyzes thermal processes in mixtures with regard to the criterion of minimum entropy generation and minimum exergy destruction. Unit 3 introduces the student to the radiation of heat through the partially permeable media, and enables him to calculate the radiation energy exchange between the bodies with arbitrary spatial arrangement. Unit 4 discusses Kinetic theory of gases, Maxwell distribution of molecular velocity, and transport coefficients in constitutive equations. Unit 5 explains how to implement chemical reaction into the mathematical model. Unit 6 describes the basic lows in cases of multi-component or multi-phase flows and discuss Euler-Euler and Euler-Lagrange approaches. Also the VOF method is discussed.

Lecturers: Prof. Zdravko Virag, Prof. Mario Šavar, Prof. Ivanka Boras, Asst. Prof. Saša Mudrinić, Asst. Prof. Nenad Ferdelji

Literature:

1. Bird, R.B., Stewart, E.W., Lightfoot, N.,E.: Transport Phenomena, Second Edition, John Wiley&Sons Inc., New York, 2002.
2. Bejan, A.: Entropy Minimization Optimization, CRC Press, Boca Raton, 1996.
3. Wark, K.(Jr.): Advanced Thermodynamics for Engineers, McGraw Hill, New York, 1995.

ISVU Number: 156214

ECTS Credits: 6

Semester: winter

English Level: R2

Advanced Control for Energy Efficiency and Demand Response in Smart Grids

Course Description:

The course objective is to teach students modeling, analysis and implementation of advanced control with the goal of increased energy efficiency and demand response in smart grids. Practical examples that will be presented are typical engineering processes and systems in building and industry sectors. The course will be divided into chapters that will cover a) basic methods of advanced control and possibilities for demand participation in smart grids, b) basic theory and applications of different optimization methods, c) development of models for simulation of a dynamic system response when exposed to external forcing parameters, d) planning of an experiment for the collection of data that are needed for model calibration and validation, e) model calibration, validation and sensitivity analysis, f) formation of the optimization problem and mathematical algorithms its solution, g) development of the methodology for implementation of advanced control in a real process and the estimation of capital costs, h) the analysis of energy savings and operative costs. The course will also include innovative individual projects that will incorporate many of these concepts with the goal of advanced control implementation and the optimization of system's demand response using computer simulations and experimental measurements.

Lecturers: Asst. Prof. Tea Žakula, Assoc. Prof. Andrej Jokić

Literature:

1. Boyd S, Vandenberghe L. Convex Optimization. Cambridge University Press, New York, USA, 2004.
2. Mayne D. Q., Rawlings J. B., Rao C. V., Scokaert P. O. M. 2000. Constrained model predictive control: Stability and optimality. Automatica 36, pages 789-814.
3. Qin S. J., Badgwell T. A. 2003. A survey of industrial model predictive control technology. Control Engineering Practice 11, pages 733–764.

ISVU Number: 185935

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Advanced Quantitative Infrared Thermography

Course Description:

To familiarize students with infrared thermography and its application in preventive maintenance, non-destructive testing and measurement of temperature and temperature distribution in the plant process engineering, electrical and building sectors. To give approach for development of the new quantitative infrared thermography methods.

Lecturers: Prof. Ivanka Boras

Literature:

1. M. Andrassy; I. Boras; S. Švaić, Osnove termografije s primjenom, Kigen, Zagreb 2008.
2. Xavier P.V. Maldague, Theory and Practice of Infrared Technology for Nondesctructive Testing, John Wiley & Sons, New York, USA, 2001.
3. Gerald C. Holst, Common sense approach to thermal imaging, Spie optical engineering press, Washington, USA, 2000.

ISVU Number: 156207

ECTS Credits: 6

Semester: summer/winter

English Level: R2

Advanced Thermal Measurements

Course Description:

To train students for research and implementation of components of measurement systems including: Importance of measurement in research, measurement traceability, uncertainty of measurement. Measurement of temperature: International temperature scale ITS-90, thermometers, surface temperature measurement. Measurement of pressure: Manometers, vakuummeters, barometers, presure transducers. Measurement of quantity and flow: Determination of quantity, weighing and measurement of volume, measurement of mass and volume flow, volume correctors, measurement of fluid velocity. Humidity measurement: Direct methods, dew-point hygrometers, relative humidity meters. Measurement of flue gas composition: Chemical analyzers, physical analyzers. Measurement of heat energy: Calculator units, flow meters, thermometers. Measurement of level: Direct methods, indirect methods. Measurement of thermophysical properties: Heat conductivity, heat capacity, heat flux.

Lecturers: Prof. Davor Zvizdić, Prof. Martti Heinonen

Literature:

1. Benedict R.P. Fundamentals of Temperature, Pressure and Flow Measurements, Part II , John Wiley & Sons, New York, 1969.

ISVU Number: 156172

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Computational Fluid Dynamics

Course Description:

To familiarize with the turbulence models. Introduction to the finite volume method for the fluid flow and heat transfer prediction. To understand the basic characteristics of numerical methods as a basis for competent usage of commercial CFD codes.

Learning outcomes: run a CFD computer code, use postprocesor to display obtained results, analyse competently obtained results.

Student will be skilled in: selecting turbulence model and boundary conditions, selecting parameters that influence efficiency of numerical procedure, to refine computational mesh to achieve better results, to estimate accuracy of obtained results.

Lecturers: Prof. Zdravko Virag, Prof. Ivo Džijan

Literature:

1. J. Ferziger, M. Perić: Computational Methods for Fluid Dynamics, Springer-Verlag Berlin Heidelberg, 3. ed. (2002).
2. John F. Wendt (ed.): Computational Fluid Dynamics – An Introduction: Springer-Verlag Berlin Heidelberg (2009).

ISVU Number: 156213

ECTS Credits: 6

Semester: summer/winter

English Level: R2

Cooling-Heating Processes with Heat Pumps

Course Description:

The aim of this course is to provide advanced knowledge in refrigeration and heat pump technology using different operating energy and different renewable energy sources. Application and analysis or renewable energy sources: ground, water, air, direct solar energy. Ground source heat pumps. Transient processes in the ground. Practical work. Air source heat pumps. Practical work. Ground and surface water as heat source/sink.

Comparison of heat pumps with conventional heating and cooling systems. Economic and ecological measures for validation of different heating and cooling systems.

Lecturers: Prof. Vladimir Soldo

Literature:

1. J. Egg, G. Cunniff, C.D. Orio, Modern geothermal HVAC, McGraw- Hill, 2013.
2. Dincer, M. Kanoglu, Refrigeration systems and applications, Wiley, 2010.
3. S.K. Wang, Handbook of air conditioning and refrigeration, McGraw-Hill, 2000.
4. B. Whitman, B. Johnson, J. Tomczyk, E. Silberstein, Refrigeration & Air Conditioning Technology, Delmar cengage Learning, 2013.

ISVU Number: 156208

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Development of Modern Thermal Power Plants

Course Description:

Analysis of the requirements placed on the development of thermal power plants by 2020. from the standpoint of technical feasibility and operational characteristics. Analysis of the technical possibilities of development of thermal power plants with high steam parameters for different fuels. Analysis of influential factors on lifetime of the power plant unit (block). Analysis of the impact of high steam parameters on the lifetime of the main components of the power plant unit (block) in different designed regimes of operation. Steam generators of new generation. Operational characteristics of thermal power plants with a combined gas and steam process (combined-blocks). Application of advanced technologies in thermal power plants (TPP): steam generators with ultra-supercritical parameters, Cheng cycle-steam injection gas turbine, Stirling engine, integration of high-temperature fuel cells in TPP (e.g. solid oxides-SOFC), catalytic combustion, organic Rankine cycle (ORC), integrated gasification processes, Oxy fuel coal-fired TPP (with carbon capture and storage-CCS), hot air turbine cycle (indirect gas turbine cycle), inverse gas turbine cycle, etc.).

Lecturers: Prof. Daniel Rolph Schneider

Literature:

1. Kautz, H. & co, Das neuzeitliche Kohlekraftwerk: Lösung für Konstruktions- und Werkstoffprobleme, Expert Verlag, Renningen-Malmsheim, 1996.
2. Kashiwahara, K and Tagishi, A., Coal-fired power generation systems for the future, Thermal power division, Hitachi, ltd. Tokyo, Japan, 1999-2005. World Energy Council.
3. Thomas C. Elliott, Kao Chen, Robert Swanekamp, Standard Handbook of Powerplant Engineering, Amazon.com

ISVU Number: 156220

ECTS Credits: 6

Semester: summer/winter

English Level: R2

Dynamics and Control of Thermo-Hydraulic Processes

Course Description:

With respect to process dynamics power and process plants are characterised by complex continuous processes, strong nonlinearity, interaction among subsystems and distributed parameters. All stated is especially significant in transient operating regimes relevant for wide spectrum of plant's characteristics, such as energetic and ecological efficiency, life cycle and flexibility. Formulation of optimal operating strategy of technological processes requires detailed insight in processes dynamics. The course purpose is to extend knowledge on process dynamics and control based on simplified plant's models and to provide foundations for both research of thermo-hydraulic processes with distributed parameters and for control problems formulation and solution.

Lecturer: Prof. Dražen Lončar

Literature:

1. Thomas E. Marlin, Process Control: Designing Process and Control Systems for Dynamic Performance, McGraw-Hill, New York, 1995.
2. Silebi, C.A., W.E. Schiesser, Dynamic Modeling of Transport Process Systems, Academic Press, Inc., San Diego, 1992.
3. Balmer, L., Signals and Systems, An Introduction, 2nd Edition, Prentice Hall Europe, 1997.
4. Flynn D. (editor), Thermal Power Plant Simulation and Control, The Institution of Electrical Engineers, London, 2003.

ISVU Number: 156056

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Energy and Environmental Protection

Course Description:

Introduction to the significant parameters of water, air and soil quality (i.e. the environment) and the relevant regulations in the EU and Croatia. Overview of pollutants relevant to the energy sector for both conventional and renewable sources. Systematization of major technologies for reducing emissions, understanding of basic principles, technological capabilities and operating limits. Adoption of the methodologies for assessing the impact on the environment such as: material flow analysis (MFA) and life cycle assessment (LCA) according to ISO 14040 and 14044.

The final section – the application of methodologies for specific examples in energy transformations. The summary effects of the application of specific measures or technical solutions in terms of mitigation of adverse environmental impacts of the energy sector will be analyzed.

The examples of environmental management systems (EMS – Environmental Management Systems), according to ISO 14001 standard, in the energy sector.

Lecturers: Assoc. Prof. Slaven Dobrović, Assoc. Prof. Hrvoje Juretić, Prof. Davor Ljubas

Literature:

1. R.A. Hinrichs, M. Kleinbach, Energy – It's Use and the Environment; Third Edition, Harcourt College Publishers, 2002.
2. D. Vallero, Fundamentals of air pollution; Fourth Edition, Academic Press, Elsevier, 2008.
3. J.B. Guinée et al., Handbook on Life Cycle Assessment Operational Guide to the ISO Standards, Kluwer academic publishers, 2004.

ISVU Number: 156166

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Energy Planning Methods

Course Description:

To train students for the energy systems planning, with particular emphasis on energy systems with a high penetration of renewable energy sources, modeling the demand and supply of energy and strategic thinking, taking into account available resources and technology, and economic, environmental and social factors. Introducing to students advanced energy planning methods for systems with a high share of renewable energy from intermittent sources (Renewislands and FAST). Analysis of the overall potential of renewable energy sources in a particular area and the needs for energy and other resources at the level of individual sectors of the economy. Assessment of the flexibility needs of energy systems for existing and future installed production capacity, energy storage, power management and regulation of the energy market. Setting the single and multi objective functions for optimization of energy systems under given constraints in short-term and long-term energy planning. Mastering the basics of computer programs for advanced energy planning (EnergyPLAN, Homer, H2RES, LEAP) and acquiring the needed skills for further independent research.

Lecturers: Prof. Neven Duić, Assoc. Prof. Goran Krajačić, Prof. Henrik Lund

Literature:

1. Maxime Kleinpeter: Energy Planning and Policy, UNESCO Energy Engineering Learning Programme, John Wiley & Son Ltd, 1996
2. International Energy Agency : Energy Technology Perspectives 2012: Pathways to a Clean Energy System, OECD Publishing, 2012
3. Clark W. Gellings: Demand-Side Management Planning, Fairmont Press, 1993
4. Henrik Lund: EnergyPLAN Advanced Energy Systems Analysis Computer Model – Documentation Version 10.0, Aalborg University, Denmark 2012
5. Joel N. Swisher, Gilberto S. de Martino Jannuzzi, Robert Y. Redlinger: Tools and Methods for Integrated Resource Planning: Improving Energy Efficiency and Protecting the Environment, UNEP Collaborating Centre on Energy and Environment, Risø National Laboratory, Denmark, 1997
6. International Energy Agency, Harnessing Variable Renewables: A Guide to the Balancing Challenge, OECD Publishing, 2011

ISVU Number: 156082

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Evaporative Devices

Note: course not offered in 2020-2021 academic year.

Course Description:

The aim is to learn about the basic laws of evaporation, to get familiar with the most important types of evaporative devices and to learn about the rating procedures for such devices. To conduct a detailed research in the processes within evaporative devices. To explore the possibilities of mathematical modeling of the operation of such devices. To mark the parameters that affect the process, the intensity and direction of their influence and the possibilities of improving the performance of an evaporative device.

Literature:

1. F. Bošnjaković, Nauka o toplini II, Tehnička knjiga, Zagreb, 1976.
2. P. Berliner, Kühltürme, Springer Verlag, Berlin, 1967.

ISVU Number: 156219

ECTS Credits: 6

Semester: summer/winter

English Level: R0

Experimental Methods in Heat and Mass Transfer

Course Description:

Getting acquainted with the experimental approach to scientific research and development of components for process and thermal engineering. Connection of theory and practice. Experimental methods in R&D. Establishment of experiments and selection of measurement method and result evaluation. How to use experiments and simulations. Application of computers and mathematical methods. Measurement result presentation and determining of measurement uncertainty. New knowledge and solutions resulting from experimental research and their application.

Lecturer: Prof. Damir Dović

Literature:

1. M. Brezinšćak: Mjerenje i računanje u tehnici i znanosti, Tehnička knjiga Zagreb.
2. V.A. Grigorjeva; V.M. Zorina: Termotehnički pokus u prijenosu topline i tvari, Energizdat, Moskva 1982.
3. VDI Waermeatlas, Springer Verlag, Berlin.
4. J.P.Holman: Heat Transfer, International Student Edition, Mc Graw-Hill.

ISVU Number: 156102

ECTS Credits: 6

Semester: summer/winter

English Level: R2

Mesuremnt and Calibration Systems

Course Description:

To train students to understand and apply in their scientific and research activities: Measurement traceability of heat and process quantities. International and national standards, accredited testing and calibration laboratories, accreditation systems. Metrology standards for heat and process quantities (temperature, pressure, humidity, flow, masss, volume), transfer of measurement traceability and estimation of calibration uncertainties. Measurement systems: data acquisition, conversion, data logging and processing of measurement signals. Measurement information systems.

Lecturers: Prof. Davor Zvizdić, Prof. Martti Heinonen

Literature:

1. BIPM, Supplementary Information for the International Temperature Scale, BIPM, Sevres 1990.

ISVU Number: 156173

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Methods for Useful Life Estimation of Power Equipment and Machines

Course Description:

1. Introduction: definition of useful life, characteristics of material fatigue, needs for calculation and research of useful life, engineering and technological aspects; 2. Factors that affect the useful life: design and construction, materials, characteristics of technological process, the history of exploitation, 3. Fatigue: high cyle fatigue; low cycle (thermomechanical) fatigue, types of analysis, fatigue and fracture mechanics; 4. Methods for determining the useful life in the conditions of low cyclic (thermomechanical) fatigue: determining types of stress and deformation cycles, determination of deformations and stresses for different loading cycles (regime), determination the useful life to the appearance of crack by different models, determining the useful life after the appearance of crack – remaining useful life.

Lecturers: Prof. Zvonimir Guzović

Literature:

1. T.L. Anderson: Fracture Mechanics – Fundamentals and Applications, 3rd Edition, Taylor & Francis, New York, 2005.
2. E.E. Gdoutos, C.A. Rodopoulos: Problems of Fracture Mechanics and Fatigue – A Solution Guide, Kluwer Academic Publishers, Norwell, USA, 2003.
3. B. Farahmand, G. Bockrath, J. Glassco: Fatigue and Fracture Mechanics of High Risk Parts – Application of LEFM & FMDM Theory, Springer, 1997.
4. L. Remy, J. Petit: Temperature – Fatigue Interaction, Elsevier 2002..
5. G.A. Webster, R.A. Ainsworth: High Temperature Component Life Assessment, Chapman & Hall, London, 2010.
6. M. Steen, J.L. Valles, J. Bressers, L. Remy: Fatigue under Thermal and Mechanical Loading – Mechanism, Mechanics and Modelling, Kluwer Academic Publishers, Petten, 1995.
7. J. Ginsztles, R.P. Skelton: Component Reliability under Creep – Fatigue Conditions, Springer, Wien – New York, 1998.
8. R.I. Stephens, A. Fatemi, R.R. Stephens, H.O. Fuchs: Metal Fatigue in Engineering, 2nd Edition, John Wiley & Sons, New york, 2001.
9. J. Draper: Modern Metal Fatigue Analysis, EMAS, 2008.
10. C. Lalanne: Fatigue Damage, ISTE – Wiley, 2009.

ISVU Number: 156205

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Metrology of Heat and Process Quantities

Course Description:

To train students for research and development of components for measurement of heat and process quantities. Content is related to the metrology of: temperature, pressure, flow, mass relative humidity measurements. For each physical quantity three lectures are reserved including overview of standard systems, actual research problems and measurement uncertainty evaluation.

Lecturers: Prof. Davor Zvizdić, Prof. Lovorka Grgec Bermanec

Literature:

1. ISO/TAG4/WG3, IEC, OIML and BIPM: Guide to the Expression of Uncertainty in Measurement, 2st ed, 1995.

ISVU Number: 156174

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Modelling and Approximation in Heat and Mass Transfer Processes

Course Description:

The course objective is to teach students how to approximate and simplify the problem in order to enable modeling and the analysis of complex heat and mass transfer processes for which there is no exact solution and for which the use of complex computer simulations and numerical methods is not cost-effective or feasible. Due to a great diversity of heat and mass transfer processes, as well as a variety of their practical usage, an analysis of a specific thermodynamic problem is almost never feasible by the direct use of existing models. This course will enable students to master the methodology that can be used for the development of new thermodynamic models, independently of a heat and mass transfer subdomain that they belong to. Using real examples from the area of applied thermodynamics, students will learn the basic steps required to describe physical problems. This also includes mastering of specific modeling techniques that can later be used for the development of one's physical model for the wide range of interdisciplinary research. Practical examples that will be presented are typical engineering processes and systems from manufacturing industry, building industry and energy conversion technologies. The course will be divided into chapters that will cover basic modeling and approximation methods for specific modes of heat and mass transfer, such as heat conduction, convection and long-waive radiation, as well as phase changes and steady and transient processes. The course will also include innovative individual projects that will incorporate many of these concepts with the goal of model validation and sensitivity analysis using computer simulations and experimental measurements.

Lecturers: Asst. Prof. Tea Žakula, Asst. Prof. Nenad Ferdelji

Literature:

1. Glicksman L. R., Lienhard V J. H. Modeling and Approximation in Heat Transfer. Cambridge University Press, New York, USA, 2016.
2. Bergman T. L., Lavine A. S. Lavine, Incropera F. P.,Dewitt D. P. Fundamentals of Heat and Mass Transfer. 7th Edition. John Wiley & Sons, Hoboken, USA, 2011.
3. Bird B. R., Stewart W. E., Lightfoot E. N. Transport Phenomena, 2nd Edition. John Wiley & Sons, New York, USA, 2007.

ISVU Number: 185936

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Modelling of Combustion and Radiative Heat Transfer

Course Description:

Introduction to processes of combustion and heat radiation, and methods for their calculations inside furnaces, boilers and combustion chambers. The objective is to provide the required foundation for students involved in research on any aspect of reacting flow, combustion and radiation, to be familiar with mathematical modelling and numerical simulations, which then can serve as guidance toward greater understanding of combustion and radiation processes that is required for producing combustion devices with ever higher efficiency and with lower pollutant emissions. Students will be required to carry out research on any aspect of reacting flow, combustion and radiation.

Lecturers: Prof. Neven Duić, Prof. Daniel Rolph Schneider, Asst. Prof. Milan Vujanović

Literature:

1. Görner, K., Technishe Verbrennungssysteme, Grundlage, Modellbildung, Simulation,Springer Verlag, Berlin, 1991.
2. Kuo, K.K., Principles of Combustion, John Wiley & Sons, New York, 1986.
3. Siegel.R. and Howell,J.R., Thermal Radiation Heat Transfer, second edition, Hemisphere Publishing Corporation, Washington, 1981.
4. Duić, Neven. Prilog matematičkom modeliranju izgaranja plinovitog goriva u ložištu generatora pare / doktorska disertacija. Zagreb : FSB, 24.04.1998 , 171 str. Mentor: Bogdan, Željko.
5. Vujanović, Milan. Numerical modelling of multiphase flow in combustion of liquid fuel / doktorska disertacija. Zagreb : FSB, 20.05. 2010, 140 str. Mentor: Duić, Neven

ISVU Number: 156081

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Numerical Methods in Heat Transfer

Course Description:

Students will be familiarised with advanced numerical methods used in continuum mechanics, with emphasis on the numerical heat and mass transfer. The objective is to provide advanced knowledge for numerical modeling of heat transfer and fluid flow phenomena, to be familiar with mathematical modelling and numerical simulations, which then can serve as guidance toward greater understanding of real processes in modern engineering systems. Students will be required to carry out research on one of the topics in the area of numerical fluid dynamics.

Lecturers: Asst. Prof. Milan Vujanović, Prof. Neven Duić

Literature:

1. D.A. Anderson, J.C. Tanchill, R.H. Pletcher, Computational flud mechanic and heat transfer, Hemisphere, New York, 1984.
2. R.S. Hirsch, Numerical Computation of Internal and External Flows, vol. I i II, John Wiley and Sons, New York, Brisbone, Toronto, Singapour, 1991.
3. S.V . Patankar, Numerical Heat Transfer and Fluid Flow, chap. 6, Hemisphere, Washington, D.C. and Mc Graw-Hill, New York, 1985.

ISVU Number: 156083

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Numerical Simulations in Energy Conversion Processes

Course Description:

Students will be familiarized with process of building of numerical model for simulating different phenomenon connected with energy conversion processes. Following objects and phenomenon will be elaborated: turbomachineries, steam generators, external flows, heat transfer, fluid structure interaction, thermal stresses, acoustics and noise.

Lecturers: Assoc. Prof. Željko Tuković, Prof. Hrvoje Jasak

Literature:

1. H. K. Versteeg, W. Malalasekera, An Introduction to Coputational Fluid Dynamics: The Finite Volume Method, Prentice Hall, 2007.
2. R.S. Hirsch, Numerical Computation of Internal and External Flows, vol. I i II, John Wiley and Sons, New York, Brisbone, Toronto, Singapur, 1991.
3. D.A. Anderson, J.C. Tanchill, R.H. Pletcher, Computational flud mechanic and heat transfer, Hemisphere, New York, 1984.

ISVU Number: 156050

ECTS Credits: 6

Semester: summer/winter

English Level: R2

Selected Chapters from the Theory of Turbomachines

Course Description:

Deepening the knowledges about the principle of turbomachines: flow energy, flow with and without losses, nozzles and diffusers, types of turbomachines, Euler turbomachinery equation, Joukowski theorem. Turbomachinery stage modeling: geometric, kinematic and dynamic similarity, similar working conditions of turbomachines. Two-dimensional theory of turbomachines: Physical phenomena in the stage of axial and radial turbomachinery. Methods for calculation of the flow. Determination of profile losses. Supersonic flow. Three-dimensional theory of turbomachines: spatial method of turbomachinery stage profiling. Secondary flows in three-dimensional channels. Energy losses: Distribution of losses. Non-stationary phenomena in turbomachines. Characteristics and methods of calculation of the flow part of turbomachinery: Axial, radial-axial and radial turbomachines design. Parasitic phenomena (rotating stall of flow, cavitation, wet steam). Multistage turbomachinery design methods. Numerical modeling of flow in turbomachines.

Lecturers: Prof. Zvonimir Guzović, Assoc. Prof. Željko Tuković

Literature:

1. S.L. Dixon, C.A. Hall: Fluid Mechanics and Thermodynamics of Turbomachinery, Elsevier, New York, 2010.
2. R.H. Aungier: Turbine Aerodynamics – Axial Flow and Radial -inflow Turbine Design and Analysis, ASME, New York, 2006.
3. M.E.Dejc, B.M. Trojanovski: Untersuchung und Berechnung axialer Turbinestufen, VEB Verlag Technik, Berlin, 1973.
4. J.H. Horlock: Axial Flow Compressors and Tubines, Robert E. Krieger Publishing Company, Huntington, New York, 1973.
5. J.H.Holock: Axial flow turbines, Robert E. Krieger Publishing Comany, New York, 1973.
6. I.I. Kirillov: Teorija turbomašin, Mašinostroenie, Moskva, 1996.
7. W.W. Peng: Fundamentals of Turbomachinery, John Wiley & Sons, Inc., New Jersey, 2008.

ISVU Number: 156204

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Storage of Thermal Energy in Buildings and Industry

Course Description:

Passive and active storage of heating and cooling energy in building sector and industry within temperature range -40°C and 200°C through energy and exergy analysis, numerical modeling and simulation of dynamical nature of heat storage and heat transfer in:

1. buildings (construction elements: walls/roofs/floors/ ceilings and insulation materials).

2. passive heating and cooling of buildings with intention of efficient utilization of renewable energy sources (sun and air): energy efficient architectural building design and construction; storage and distribution of heating and cooling energy in low energy and passive buildings; utilization of new construction materials; double facades sunspaces, winter-gardens with intention to minimize primary energy consumption.

3. active storage and distribution of heating and cooling energy: sources of heating and cooling energy (renewable and conventional energy sources):,characteristics of heating and cooling energy consumption; material types: sensible (water, mixtures of water and salts/alcohols, concrete, rock, ground), latent (slurries, PCM-phase changing materials); storage period (diurnal and seasonal); storage performance in charging and discharging; containers design; storage systems design; operation strategies; storage system regulation; measurements; economical and ecological benefits.

Lecturer: Assoc. Prof. Marino Grozdek

Literature:

1. Ibrahim Dincer, Marc A. Rosen: Thermal energy storage systems and applications, Wiley, UK.
2. Charles E. Dorgan, James S. Elleson: Design guide for cool thermal storage, ASHRAE, Atlanta, Georgia.

ISVU Number: 156162

ECTS Credits: 6

Semester: summer/winter

English Level: R3

The Flow, Thermal and Mechanical Phenomena in Turbomachines

Course Description:

Flow: Modelling of stationary and transient phenomena in design and off-design flow conditions in turbomachines cascades. Flow optimal geometric parameters of profile cascades of turbomachinery. Parasitic flow phenomena in turbomachines.

Thermal load of turbomachinery elements: Modelling of stationary and transient temperature fields in turbomachinery elements. Thermal and hydraulic boundary conditions on the characteristic places of thermal turbomachinery elements.

Mechanical load of turbomachinery elements : Modeling of total stresses, dynamic phenomena, the origin and propagation of cracks, determining of the remaining useful life turbomachines elements.

Lecturers: Prof. Zvonimir Guzović, Prof. Hrvoje Jasak

Literature:

1. Kim, J.H. and Yaang, W.J., Transport Phenomena in Rotating Machinery, Hemispher Publishing Corporation, New York, London, 1988.
2. Kim, J.H. and Yaang, W.J., Dynamics of Rotating Machinery, Hemispher Publishing Corporation, New York, London, 1988.
3. Owen, J.M. and Roges, R.H.,Flow and Heat Transfer in Rotating-Disc Systems, John Wiley & Sons INC., New York, Toronto, 1989.
4. Žišina, L.M., Teploobmen v turbomašinah, Mašinostroenie, Lenjingrad, 1974.
5. Frolov, K.V., Izrailev, Yu.L, Makhutov, N.A., Morozov, E.M. and Parton, V.Z. (1991), Thermal Stresses and Strength of Turbines – Calculation and Design, Hemisphere Publishing Corporation, New York-Washington-Philadelphia-London.
6. Guzović, Z., Design and Strength of Steam and Gas Turbine Parts (in Croatian), Faculty of Mechanical Engineering and Naval Architecture, University of Zagreb, Zagreb, 1994.
7. Truhniy, A.D. (1990), Stationary Steam Turbines (in Russian), Energoatomizdat, Moscow.
8. Kostyuk, A. and Frolov. V. (1988), "Steam and Gas Turbines", Mir Publishers, Moscow.
9. Dejc, M.E. and Filippov, G.A., Gas-Dynamics of Two-Phase Flows, (in Russian), Energija, Moscow, 1968.
10. Guzovic, Z. (1998), Applicability of Existing Correlations for Heat Transfer Determination at Steam and Gas Turbines (in Croatian with abstract on English), Ph.D. Thesis, Faculty of Mechanical Engineering and Naval Architecture, Zagreb.

ISVU Number: 156206

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Thermal Apparatus and Equipment

Course Description:

Overview of apparatus for process and thermal engineering. The role of thermal apparatus in the process. Heat exchangers, evaporators, condensers, cooling towers, reactors, columns. Design principles and heat transfer. Thermodynamic, hydraulic and stress calculations.

Lecturers: Prof. Damir Dović

Literature:

1. E. Klapp: Apparate und Anlagentechnik, Springer Verlag, Berlin.
2. H. Titze: Elemente des Apparatebaues, Springer Verlag, Berlin.
3. E.E. Ludwig: Applied process design for chemical and petrochemical plants vol. I, II and III, Gulf Publish Co. Huston, USA.
4. VDI-Waermeatlas, Springer Verlag, Berlin

ISVU Number: 156106

ECTS Credits: 6

Semester: summer/winter

English Level: R2

Transients in Pipelines

Course Description:

To educate students in the fluid flow modeling for the complex pipeline networks. A Basic knowledge of the calculating methods for steady and unsteady fluid flow will be presented. A water hammer problem will be study with a special attention.

Lecturers: Prof. Ivo Džijan, Prof. Mario Šavar

Literature:

1. Fox, J.A. : Hydraulic Analysis of Unsteady Flow in Pipe Networks, MacMillan Press, London, 1987.
2. Wylie, E.B.; Streeter, V.L.; Suo, L.: Fluid Transients in Systems, Prentice Hall, 1993.
3. Osiadacz, A.J.: Simulation and Analysis of Gas Networks, Gulf Publishing Company, London, 1987.

ISVU Number: 156196

ECTS Credits: 6

Semester: summer/winter

English Level: R2

Wind and Structures

Course Description:

Following topics will be presented in lectures: atmospheric boundary layer flow, atmospheric turbulence, building, vehicle and wind turbine aerodynamics, wind loading of buildings, vehicles and wind turbines, experimental and computational research tools. Students will be required to carry out research on one of the topics listed above and write a paper.

Lecturer: Prof. Hrvoje Kozmar

Literature:

1. Sockel Helmut: Aerodynamik der Bauwerke, Friedr. Vieweg & Sohn, 1984.
2. Simiu Emil, Scanlan Robert H.: Wind Effects on Structures, John Wiley & Sons, 1986.
3. Wolf-Heinrich Hucho: Aerodynamik der stumpfen Körper, Friedr. Vieweg & Sohn, 2002.
4. John D. Holmes: Wind loading of structures, Spon Press, 2001.

ISVU Number: 156126

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Study module:

Scientific Metrology

List of fundamental elective courses of the doctoral study module:

1. Advanced Statistical Methods in Metrology
2. Fundamental Metrology
3. Numerical Linear Algebra

List of elective courses of the doctoral study module:

1. Dimensional Measurements – Advanced Methods
2. Dimensional Nanometrology
3. Measuring of Force and Hardness
4. Methods for Estimating Measurement Uncertainty
5. Metrology of Heat and Process Quantities
6. Nondestructive Evaluation Methods
7. Physical Principles of Metrological Instruments and Microscopy

Advanced Statistical Methods in Metrology

Course Description:

Statistics in the function of basic measurement terms. (Bias, Linearity, Accuracy, Precision, Repeatability, Reproducibility). Statistical methods for assessing the quality of the measurement system (Range method, Average & Range method, ANOVA method). Statistical analysis of interlaboratory comparisons according to the ISO 5725. Bayesian approach to key comparisons. The application of simulations in metrology. Theoretical basis of the simulations. Data distributions. Using random numbers to generate probability distributions: Normal, Uniform, Triangular, U shaped, Weibull, Exponential. The steps to be followed for evaluating and expressing the uncertainty of measurement results according to GUM and MCS methods. Statistical Tolerancing. Worst Case analysis, Root Sum of Squares (RSS) analysis. Six Sigma Tolerance Analysis.

Lecturer: Prof. Biserka Runje

Literature:

1. Data Modeling for Metrology and Testing in Measurement Science. Franco Pavese, Alistair B. Forbes. ISBN 978-0-8176-4592-2 e-ISBN 978-0-8176-4804-6 DOI 10.1007/978-0-8176-4804-6 Birkhäuser Boston, a part of Springer Science+Business Media, LLC 2009
2. Krystek M, Bosse H 2010 A Bayesian approach to the linking of key comparisons to be published
3. M G Cox and P M Harris. Evaluation of key comparison data using key comparison reference curves. Metrologia49(2012) 437–445
4. ISO 5725-5/COR1:2005 Accuracy (trueness and precision) of measurement methods and results – Part 5: Alternative methods for the determination of the precision of a standard measurement method – Corrigendum
5. ISO 5725-6:2001 Accuracy (trueness and precision) of measurement methods and results – Part 6: Use in practice of accuracy values
6. Automotive Industry Action Group (2010). Measurement Systems Analysis Ref-erence Manual, 4th Edition, Chrysler Group LLC, Ford Motor Company and General Motors Corporation.

ISVU Number: 156087

ECTS Credits: 6

Semester: winter

English Level: R3

Fundamental Metrology

Course Description:

Students will acquire knowledge in: Present realization of physical SI-units and problems and weaknesses in their realization; Current realization of measurement units: primary, international and national standards; Methods of traceability transfer; The Metre Convention, CIPM and CIPM MRA; Metrology intercomparisons- EURAMET, CIPM MRA KCDB database of CMC values; Fundamental metrology in Croatia- structure and activities of HMI, current results and future goals.

Lecturers: Asst. Prof. Marko Katić, Prof. Davor Zvizdić

Literature:

1. Resolution 1 of the CGPM (2011): On the possible future revision of the International System of Units, the SI
2. Ian M. Mills, Peter J. Mohr, Terry J. Quinn, Barry N. Taylor, and Edwin R. Williams: Adapting the International System of Units to the twenty-first century, Phil. Trans. R. Soc. A. 2011 369 3907-3924 doi:10.1098/rsta.2011.0180 (published 19 September 2011)
3. Peter Becker and Horst Bettin: The Avogadro constant: determining the number of atoms in a single-crystal 28Si sphere, Phil. Trans. R. Soc. A. 2011 369 3925-3935 doi:10.1098/rsta.2011.0222 (published 19 September 2011)
4. M. Stock: The watt balance: determination of the Planck constant and redefinition of the kilogram Phil. Trans. R. Soc. A. 2011 369 3936-3953 doi:10.1098/rsta.2011.0184 (published 19 September 2011)
5. R. S. Davis: The role of the international prototype of the kilogram after redefinition of the International System of Units, Phil. Trans. R. Soc. A. 2011 369 3975-3992 doi:10.1098/rsta.2011.0181 (published 19 September 2011)
6. Martin J. T. Milton: A new definition for the mole based on the Avogadro constant: a journey from physics to chemistry Phil. Trans. R. Soc. A. 2011 369 3993-4003 doi:10.1098/rsta.2011.0176 (published 19 September 2011)

ISVU Number: 156155

ECTS Credits: 6

Semester: winter

English Level: R3

Numerical Linear Algebra

Course Description:

To understand concepts of the numerical linear algebra and scientific computing with emphasys how to choose a method for solution of the problem and the possible numerical errors in obtained results. Learn how to use the numerical libraries for solution of subproblems.

Lecturer: Prof. Sanja Singer

Literature:

1. James W. Demmel, Applied Numerical Linear Algebra, SIAM, 1997.
2. Lloyd N. Trefethen and David Bau, III, Numerical Linear Algebra, SIAM 1997.

ISVU Number: 155491

ECTS Credits: 6

Semester: winter

English Level: R2

Dimensional Measurements – Advanced Methods

Course Description:

Fundamental principles and techniques of dimensional measurement. Realization of primary length standard, optical interferometry and absolute length measurement, interference comparator. Traceability of length measurement. Calibration of measuring instruments and measurement uncertainty. Applications of laser interferometers. Abbe principle and design of measuring instruments. 1D, 2D and 3D principles of dimensional measurement. Electromagnetic and optical sensors in length metrology. Measurement of complex surfaces. Geometric dimensioning and tolerancing (GD&T). Error separation methods. Roughness standards and roughness measurement methods. Angle standards and division of circle. Basics of optics, optical systems, digital image acquisition and analysis. 3D optical scanning and fringe projection systems. Object-oriented photogrammetry- measurement of deflection and deformation.

Lecturers: Asst. Prof Marko Katić, Prof. Đuro Barković, PhD Nenad Drvar

Literature:

1. G. Timp, Nanotechnology, Springer- Verlag, New York, 1999.
2. D.J.Whitehouse, "The Handbook of Surface and Nanometrology", Institute of Physics Pub, 1999.
3. F.T.Farago, M.A.Curtis, "Handbook of Dimensional Measurement", Industrial Press Inc. New York, 1994.
4. K.J.Gasvik, "Optical Metrology", John Wiley&Sons, 3rd edition, 2002.

ISVU Number: 156156

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Dimensional Nanometrology

Course Description:

Content: Introduction to nanometrology. Scope and trends in nanometrology. The function, method of obtaining, condition, properties of surfaces. Surface topography. 2D and 3D roughness parameters. Properties of optics. Types of lasers. Computer-controlled laser stabilization. Application of interferometry in length measurements. Interpretation of interferograms. Application of holography for reproduction of 3D surface structures. 2D and 3D surface topography using stylus instruments. Physical principles underlying the various groups scanning microscopes. Assuring measurement unity in the field of dimensional micro-and nanometrology. Nanometrology in Croatian National Laboratory for Length.

Objectives: Introduce students with metrology concepts and theoretical principles in the field of nanometrology. Classify and describe measurement methods in the field of dimensional nanometrology. Demonstrate measurements using optical interferometers, stylus instruments and scanning microscopes. Analyze and interpret measurement results. Indicate the problems of assuring measurement unity in the field of dimensional micro- and nanometrology.

Lecturer: Asst. Prof. Gorana Baršić

Literature:

1. International vocabulary of metrology – Basic and general concepts and associated terms (VIM), JCGM 200:2012
2. R.K. Leach, R. Boyd, T. Burke, H.-U. Danzebrink, K. Dirscherl, T. Dziomba, M. Gee, L. Koenders, V. Morazzani, A. Pidduck, D. Roy, W.E.S. Unger, A. Yacoot, Consultation on a European Strategy for Nan ometrology, 2010
3. Metrology – in short, ISBN 978-87-988154-5-7, EURAMET project 1011, participants: DFM Denmark, NPL United Kingdom, PTB Germany, 2008
4. H.N. Hansen, K. Carneiro, H. Haitjema, L. De Chiffre, Dimensional Micro and Nano Metrology, CIRP Annals – Manufacturing Technology, 2006
5. L. Koenders, R. Bergmans, J. Garnaes, J. Haycocks, N. Korolev, T. Kurosawa, F. Meli, B.C. Park, G.S. Peng, G.B. Picotto, E. Prieto, S. Gao, B. Smereczynska, T. Vorburger, G. Wilkening, Comparison on Nanometrology: Nano 2—Step height, Metrologija, Vol. 40, 2003

ISVU Number: 156097

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Measuring of Force and Hardness

Course Description:

Introduction to historical development of force and hardness measurements and present state in that field. Types, classifications and basic characteristics of metrological instruments. Principles of force and hardness measurements. Accuracy, precision, hysteresis effects, error propagation and stability of metrological instruments. Sources of measurement uncertainty and estimation of their influence on measurement. Influence of mass and gravity on force and hardness measurements of primary standards and achievements of present researches on that field. Researches to decrease measurement uncertainty of force and hardness measurement. Force measurement capability: from nanonewton to meganewton. Development trends in force and hardness measurement. Overview of present researches in the field of force and hardness measurement.

Lecturer: Assoc. Prof. Željko Alar

Literature:

1. Richard S. Figliola, Donald E. Beasley: Theory and Design for Mechanical Measurements, fifth edition, John Wiley&Sons, 2011.
2. Marc Andre Meyers, Krishan Kumar Chawla: Mechanical Behavior of Materials, second edition, Cambridge University Press 2009.
3. Calibration Guide EURAMET cg-4 Version 2.0 (03/2011): Uncertainty of Force Measurements
4. Konrad Hermann und 4 Mitautoren: Härteprüfung an Metallen und Kunststoffen, Grundlagen zu modernen Verfahren, 2007.
5. Messtechnik Schaffhausen GmbH: Grundsätzliches zur Messung von Kräften, Broschüre
6. OIML R 60: Metrological regulation for load cells, International Organization of Legal Metrology, Edition 2000 (E)

ISVU Number: 156177

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Methods for Estimating Measurement Uncertainty

Course Description:

Clarify the basis for understanding the concept of measurement uncertainty and mastering the theory and technique of assessment (Errors, effects, and corrections, Gum method, Type A evaluation of standard uncertainty, Type B evaluation of standard uncertainty, Determining combined standard uncertainty, Determining expanded uncertainty, Choosing a coverage factor, Central Limit Theorem, The t-distribution and degrees of freedom, Effective degrees of freedom).

Point out the errors and ambiguities that exist in the process of evaluating and expressing uncertainty in measurement (Measurement error –Measurement uncertainty, Repeatability – Reproducibility, Precision – Accuracy, Standard deviation-Standard uncertainty, Interpretation of the coverage interval).

Train students to use complex mathematical tools in the process of estimating measurement uncertainty (Monte Carlo simulations, Probability density function assignment for the input quantities, Sampling from probability distributions, Estimate of the output quantity, Coverage interval for the output quantity, Validation of the GUM uncertainty framework using a Monte Carlo method).

Correct expression and validation of measurement results through inter-laboratory comparison.

Lecturers: Prof. Biserka Runje, Prof. Lovorka Grgec Bermanec

Literature:

1. JCGM 100:2008 Vrednovanje mjernih podataka – Upute za iskazivanje mjerne Nesigurnosti.
2. JCGM 101:2008 Vrednovanje mjernih podataka – Dopuna 1. Uputama za iskazivanje mjerne nesigurnosti – Prijenos razdioba uporabom metode monte karlo.
3. JCGM 106: 2009 Draft Vrednovanje mjernih podataka – Uloga mjerne nesigurnosti u ocjeni sukladnosti.
4. Measurement Uncertainties – Physical Parameters and Calibration of Instruments, Gupta, S. V., Springer, 2012.
5. Michael Grabe, Uncertainties in Science and Technology, , Springer, 2005.
6. Metrologia – International journal in pure and applied metrology, published by IOP Publishing on behalf of Bureau International des Poids et Mesures (BIPM).

ISVU Number: 156092

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Metrology of Heat and Process Quantities

Course Description:

To train students for research and development of components for measurement of heat and process quantities. Content is related to the metrology of: temperature, pressure, flow, mass relative humidity measurements. For each physical quantity three lectures are reserved including overview of standard systems, actual research problems and measurement uncertainty evaluation.

Lecturers: Prof. Davor Zvizdić, Prof. Lovorka Grgec Bermanec

Literature:

1. ISO/TAG4/WG3, IEC, OIML and BIPM: Guide to the Expression of Uncertainty in Measurement, 2st ed, 1995.

ISVU Number: 156174

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Nondestructive Evaluation Methods

Course Description:

Content: Analysis of advanced Non-Destructive Evaluation (NDE) techniques and methods. Automated NDE. Excitation and evaluation of response, signal-to-noise ratio, image quality, characterization of materials. Control and assurance of repeatability and reproducibility. Reliability of non-destructive testing, statistical parameters. Probability of Detection (POD), PoD curve, spatial distribution. Design of Experiments for reliability and PoD assessment. Complementary NDE methods and techniques. Role of NDE in assessing the integrity of structures and components. Management and planning the cycles of NDE.

Goal: Understand and adopt the probabilistic concept and correlation of risk assessment and reliability of NDE for objective-based planning and management of the implementation of NDE inspections during the lifetime of structures and components.

Lecturer: Prof. Damir Markučič

Literature:

1. Chuck Hellier; Handbook of Nondestructive Evaluation; McGraw-Hill Professional; 2. edition (2012)
2. MIL-HDBK-1823A, Nondestructive Evaluation System Reliability Assessment, DoD, April 2009
3. Lester Schmerr, Jung-Sin Song; Ultrasonic Nondestructive Evaluation Systems: Models and Measurements; Springer; 1 edition (2007)
4. Peter J. Shull; Nondestructive Evaluation: Theory, Techniques, and Applications; CRC Press; 1st edition (2002)
5. B D Olin and W Q Meeker, 'Applications of statistical methods to nondestructive evaluation', Technometrics, Vol 38, No 2, pp 95-112, May 1996.

ISVU Number: 156187

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Physical Principles of Metrological Instruments and Microscopy

Course Description:

Contents: Types, classifications and basic characteristics of metrological instruments. Characteristics of electromagnetic radiation for applications in metrology (ionisation radiation, UV, light, IR, millimetar waves, microwaves) and of its interaction with matter. Metrological instruments based on the heat exchange. Metrological instruments based on the balanced contact. Referent points, traceability and calibration of metrological instruments. Accuracy, precision, hysteresis effects, error propagation and stability of metrological instruments. Influence of metrological instruments onto measured quantities. Validation of systems of metrological instruments. Light and electron microscopy. Trends in microscopy developmnet. System of modelling microstructure and microsopy. Application and preparation of samples in microscopies.

Objectives: Understand the principles of metrology instruments. Realisation of metrological system of given accuracy and precision within stated context. Introduction to methodes and techniques for materials testing, determination of structure, properties of materials. Unification of stated areas by solving complex problems.

Lecturers: Prof. Josip Stepanić, Assoc. Prof. Suzana Jakovljević

Literature:

1. Moore, J.H., et al.: ″Building Scientific Apparatus″. 4. izdanje. Cambridge University Press, 2009., ISBN 978-0521878586.
2. Yoshizawa, T.: ″Handbook of Optical Metrology: Principles and Applications″, CRC Press, 2009., ISBN 978-0521878586.
3. Wiesendanger, R.: ″Scanning Probe Microscopy and Spectroscopy: Methods and Applications″. Cambridge University Press, 1994., ISBN 0-521-42847-5
4. Reed, S.J.B.: ″Scanning electron microscopy″. Cambridge University Press, str. 41-75, 2005.,

ISVU Number: 156084

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Study module:

Theory of Structures

List of fundamental elective courses of the doctoral study module:

1. Dynamics of Machines
2. Equations of Mathematical Physics
3. Numerical Linear Algebra
4. Theory of Elasticity

List of elective courses of the doctoral study module:

1. Alternative Drives of Motor Vehicles
2. Biomechanics
3. Complex Socio-Technical Systems
4. Computationally Supported Development of the ICE and Vehicles
5. Data Management in Product Development – PLM
6. Design of High Strength Joints
7. Design Theories
8. Engines and Vehicles – Selected Topics
9. Experimental Model Techniques
10. Investigation of Thermal Processes in the IC Engine
11. Nonlinear Dynamics
12. Optical Methods of Mechanics
13. Sliding-Rolling Contacts
14. Theory of Gearing
15. Theory of Plasticity
16. Theory of Viscoelasticity
17. Vibrations of Systems with Clearances

Dynamic of Machines

Course Description:

Understaning of fundamentals and techniquies for successfull modelling, analysis, design and modification of dynamic behaviour of machines. Dynamics of Rigid Machines. Foundation and Vibration Isolation. Torsional Vibration. Bending Vibration. Optimisation of Machines with regard to vibrations.

Lecturer: Prof. Hinko Wolf, Asst. Prof. Neven Alujević

Literature:

1. John H. Argyris, Hans-Peter Mlejnek: Dynamics of structures, North-Holland, 1991.
2. H. Dresig, F. Holzweißig: Dynamics of Machinery, Springer-Verlag Berlin Heidelberg 2010.
3. Angeles, J: Dynamic Response of Linear Mechanical Systems. Modeling, Analysis and Simulation, Springer, New York, 2011.
4. P. E. Nikravesh: Planar Multibody Dynamics: Formulation, Programming and Applications, CRC Press, 2007.

ISVU Number: 156153

ECTS Credits: 6

Semester: winter

English Level: R1

Equations of Mathematical Physics

Course Description:

Familiarize students with the basic mathematical theory of boundary value problems for partial differential equations in one or more dimensions.

Lecturer: Prof. Luka Grubišić

Literature:

1. I. Aganović, K. Veselić, Linearne diferencijalne jednadžbe. Uvod u rubne probleme, skripta PMF – Matematičkog odjela, Zagreb, 1992.
2. M. R. Spiegel, Fourier analysis with applications to boundary value problems, Schaum'e, McGraw – Hill, 1974.
3. I. Aganović, K. Veselić, Jednadžbe matematičke fizike, Školska knjiga, Zagreb, 1985.

ISVU Number: 155494

ECTS Credits: 6

Semester: winter

English level: R3

Numerical Linear Algebra

Course Description:

To understand concepts of the numerical linear algebra and scientific computing with emphasys how to choose a method for solution of the problem and the possible numerical errors in obtained results. Learn how to use the numerical libraries for solution of subproblems.

Lecturer: Prof. Sanja Singer

Literature:

1. James W. Demmel, Applied Numerical Linear Algebra, SIAM, 1997.
2. Lloyd N. Trefethen and David Bau, III, Numerical Linear Algebra, SIAM 1997.

ISVU Number: 155491

ECTS Credits: 6

Semester: winter

English Level: R2

Theory of Elasticity

Course Description:

Study of the tensor of stresses and strains. Introduction to the tasks of theory of elasticity and methods of solving the problems. To teach students how to apply the methods of theory of elasticity in technical calculations.

Lecturer: Prof. Damir Semenski

Literature:

1. Jecić, S.; Semenski, D.: Jednadžbe teorije elastičnosti, Skripta sveučilišta u Zagrebu, AJA, Zagreb, 2001.
2. Herman, K.T., Teorija Elastičnoosti i plastičnosti, Zagreb 2008.
3. Kostrenčić, Z., Teorija elastičnosti, Školska knjiga, Zagreb, 1981.
4. Timošenko, S., Gudier, J.N., Teorija elastičnosti, prijevod s engleskog, Građevinska knjiga, Beograd, 1962.5. Alfirević, I., Tenzorski račun i tenzorska mehanika, Zagreb, 2007.
5. Alfirević, I., Uvod u tenzore i mehaniku kontinuuma, Zagreb, 2003.

ISVU Number: 156100

ECTS Credits: 6

Semester: winter

English Level: R2

Alternative Drives of Motor Vehicles

Course Description:

Lectures and Seminars from the field of alternative power-trains of vehicles. The themes are: Powertrain that includes Internal Combustion Engine fuelled with gasoline, diesel oil, liquefied petrol gas, compressed natural gas, biofuels, e-fuels. Powertrain that includes electrical motor (source of electricity from some storage or external). Inertial drive for vehicles. Hybrid drives for vehicles. Powertrains that are fuelled with Hydrogen.

Lecturer: Prof. Zoran Lulić

Literature:

1. German J. M.: Hybrid Powered Vehicles, SAE international, Warrendale, 2003.
2. Nemry F., Leduc G., Munoz A.: Plug-in Hybrid and Battery-Electric Vehicles: State of the research and development and comparative analysis of energy and cost efficiency, JRC Technical Notes, EC, 2009.
3. Heywood J.B.: Internal Combustion Engine Fundamentals, McGraw – Hill, New York, 1988.
4. Van Basshuysen R., Schafer F.: Internal Combustion Engine Handbook, SAE, Warrandale, 2004.
5. Zhao H.: HCCI and CAI engines for the Automotive Industry, Woodhead publishing limited, Cambridge, 2007.
6. Holt, D. J., ″Alternative Diesel Fuels″, Society of Automotive Engineers, USA, SAE Order No. PT-111, 2004

ISVU Number: 156183

ECTS Credits: 6

Semester: summer/winter

English Level: R2

Biomechanics

Course Description:

The aim of the course is application of theoretical, experimental and computational approaches in understanding the mechanics of living systems at the cellular, tissue, organ and organism level. This course concentrates on methods of formulating continuum models for hard tissue and methods for modelling and simulation of human movement. Following topics will be lectured: Bone mechanics (mechanical and architectural properties of bones, bone growth, concepts of the continuum damage mechanics, models of the bone remodelling). Bone implants (design and biological factors, the strain controlled adaptation around bone implants). Dental biomechanics (structural properties of tooth, force generation, orthodontic devices and implants – stress analysis, models of the mandible bone remodelling). Modelling and simulation of human movement (methods used to model and quantify human body motion, mechanisms involved in the production of movement, implementation of the experimental motion analysis into musculoskeletal modelling environment, models and methods for the analysis, synthesis and simulation of human motion).

Lecturers: Prof. Tanja Jurčević Lulić

Literature:

1. Cowin, S.C., Doty, S.B, Tissue Mechanics, Springer, 2007
2. Cowin, S.C., Bone Mechanics Handbook, CRC Press, 2001
3. Natali, A.N., Dental Biomechanics, Taylor and Francis, 2003
4. Winter, D.A., Biomechanics and Motor Control of Human Movement, John Wiley and Sons, Fourth Edition, 2009.

ISVU Number: 156179

ECTS Credits: 6

Semester: summer/winter

English Level: R1

Complex Socio-Technical Systems

Course Description:

The course examines the core theory and contextual applications of the emerging field of complex socio-technical systems. There is a focus on analysis of research on key concepts such as complexity, uncertainty, fragility, and robustness, as well as a critical look at the historical roots of the field and related areas such as systems theory and systems engineering. Special attention is given to the interdependence of social, natural and technical perspectives of design, creation, usage and disposal of complex socio-technical systems.

Lecturers: Prof. Mario Štorga, Asst. Prof. Stanko Škec

Literature:

1. Mitchell M. ″Complexity – A guided tour″, Oxford University Press, USA, 2009, ISBBN 978-0-19-512441-5
2. Gharajedaghi J. ″Systems thinking – managing chaos and complexity″, Morgan Kaufmann, Elsavie, 2011, ISBN 978-0-12-385915-0
3. Hu F., Mostashari A. And Xie J. ″Socio-technical networks: science and engineering design″,CRC Press Taylor and Francis, 2010, ISBN 978-1439809808
4. Newman M.E.J. ″Networks – an introduction″, Oxford University Press, 2010, ISBN 978-0-19-920666-0
5. Wolfram S. ″New Kind of Science″, Wolfram Media Inc., 2002, ISBN 978-1-579-550080
6. Hubka V. And Eder W.E. ″Theory of technical systems – a total concept theory for engineering design″, Springer Verlag, 1988, ISBN 978-0387174518

ISVU Number: 156139

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Computationally Supported Development of the ICE and Vehicles

Course Description:

Considering the extreme interdisciplinarity in the field there is a need for integration of different computational programs (coupling). Within the framework it is necessary to develop a strategic approach using various tools with different level of complexity in a given stage of development of the ICE and vehicles. Modern computational support includes various programs for simulation of the ICE, powertrain, kinematics and vehicle dynamics, aerodynamics, etc; within the course numerous software packages available on the FMENA will be used. The goal of the course is to use computer software to solve various problems in the development of specific ICE assembly or vehicle assembly.

Lecturer: Assoc. Prof. Darko Kozarac

Literature:

1. Heywood J.B.: Internal Combustion Engine Fundamentals, McGraw – Hill, New York, 1988.
2. Van Basshuysen R., Schafer F.: Internal Combustion Engine Handbook, SAE, Warrandale, 2004.
3. Stone R.: Introduction to Internal Combustion Engines, Macmillan press Ltd., London, 1999.

ISVU Number: 156182

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Data Management in Product Development – PLM

Course Description:

Introduction the functionality and implementation of the PDM and PLM systems in the companies. Similarities, differences and scope of usage of the Document Management, Product Data Management, Product Lifecycle Management, Enterprise Resource Management systems. Description of the functionality and application of the Customer Resource Management, Project Management, Change Management, Configuration Management systems. Introduction to the methods used in order to implement PLM/PDM solutions in the firm.

Lecturers: Prof. Nenad Bojčetić, Prof. Neven Pavković

Literature:

1. Saaksvuori, A. Immonen ., Product Lifecycle Management, ISBN-10: 3642096840, Springer (2008)
2. Rodger Burden, PDM: Product Data Management, ISBN-10: 0970035225, ISBN-13: 978-0970035226, Resource Publishing (May 19, 2003)
3. M. Grieves, Product Lifecycle Management: Driving the Next Generation of Lean Thinking, ISBN-10: 0071452303, McGraw-Hill (2005)

ISVU Number: 156159

ECTS Credits: 6

Semester: summer/winter

English Level: R1

Design of High Strength Joints

Course description:

The adoption of the basic principles and guidelines of proper design for welded, bolted and riveted joints. Impact of notching action on highly loaded joints structures. The aim of the course is to explore, by means of the analysis and synthesis technology of the features, functions, structures, types of load, types of materials, heat treatment, size and weight, shape and appearance, ergonomics and quality algorithms, the adoption of the principle of proper formation of support structure components. Adopt the method of calculation of structural capacity according to the guidelines EN, ISO and FEM at static and dynamic loads.

Lecturer: Asst. Prof. Matija Hoić

Literature:

1. P. Orlov: Fundamentals of machine design, Mir Publishers, 1.,2.,3.,4. i 5., Moscow 1988.
2. FEM: Rules for the design of hosting appliances, Booklet 1-9, 3rd Edition revised, 1998.

ISVU Number: 156148

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Design Theories

Course Description:

Principles and methods of design research: introduces the basic theoretical principles and methods for assembling, developing and analyzing information in the tasks of design research. Techniques for collecting data, testing hypotheses and presenting conclusions are learned in the context of conducting a pilot design research project. Philosophical context of design: the philosophical framework for conducting research and building knowledge in the field of design will be explored including concepts from epistemology, phenomenology and structuralism.

Lecturers: Prof. Mario Štorga, Prof. Neven Pavković

Literature:

1. Chakrabarti A., Blessing L.T.M, An Anthology of Theories and Models of Design, Springer, 2014. ISBN: 78-1-4471-6337-4
2. Birkhofer H., The Future of Design Methodology, Springer 2011, ISBN-13: 978-0857296146
3. Laurel B., Lunenfeld P., Design Research: Methods and Perspectives, MIT Press, 2003. ISBN: 9780262122634
4. Vermaas PE., Kroes P., Light A., Moore SA., Eds.,Philosophy and Design , Springer, 2009, 978-90-481-2733-7
5. Simon H., The sicence of the artificial – third edition, The MIT Press, 1996, ISBN 978-0-262-69191-8

ISVU Number: 156171

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Engines and Vehicles – Selected Topics

Course Description:

The aim of the course is the application of theoretical, experimental and computational approaches to the analysis and synthesis of new solutions in the field of ICE and vehicles.

PhD student selects her/his research field from the course area and analyses it in detail using the methods of scientific research.

The course includes the following topics: Combustion, The dynamics of the valvetrain, Stability and maneuverability of the vehicle, Suspension systems and vehicle vibrations, The powertrain of motor vehicles, The vehicle aerodynamics.

Lecturers: Prof. Zoran Lulić

Literature:

1. Cornel, S.:Direct Injection Systems for Spark-Ignition and Compression-Ignition Engines, Society of Automotive Engineers, USA, SAE Order No. R-289, Springer-Verlag Berlin Heidelberg, 1999
2. Hoag, K. L.: Vehicular Engine Design, Society of Automotive Engineers, USA, SAE Order No. R-369, Springer-Verlag, Wien, Austria, 2006
3. Heywood J.B.: Internal Combustion Engine Fundamentals, McGraw – Hill, New York, 1988.
4. G. Genta, L. Morello: The Automotive Chassis – Volume 1: Components Design, Springer, Nizozemska, 2009.
5. G. Genta, L. Morello: The Automotive Chassis – Volume 2: System Design, Springer, Nizozemska, 2009.
6. J. Weber: Automotive Development Processes – Processes for Successful Customer Oriented Vehicle Development, Springer-Verlag, Berlin, Njemačka, 2009.

ISVU Number: 156180

ECTS Credits: 6

Semester: summer/winter

English Level: R2

Experimental Model Techniques

Course Description:

Introduction to experimental model techniques for the determination of stress and strain in the mechanics of rigid and deformable bodies. During this course students will enhance their understanding of basic concepts and increase their ability to solve a lot of different engineering problems of an interdisciplinary nature. Application to problems in biomechanics, fracture mechanics, thermoelasticity and contact mechanics.

Lecturer: Asst. Prof. Zvonimir Tomičević

Literature:

1. Handbook of Experimental Solid Mechanics, Sharpe (Ed.), Springer, 2008.
2. Kobayasi, A. S., Handbook of Experimental Mechanics, New York, 1993.
3. Alfirević, I.; Jecić, S., Fotelasticimetrija, Liber, Zagreb, 1983.
4. Rohrbach, C., Hanbuch fur experimentelle Spannunganalyse, VDI-Verlag, Dusseldorf, 1989.
5. Radaj, D.; Vormwald, M., Ermüdungsfestigkeit, Springer, 2007.
6. Lemaitre, J.; Desmorat, R., Engineering Damage Mechanics Ductile, Creep, Fatigue and Brittle Failures, Springer, 2005.156178

ISVU Number: 156178

ECTS Credits: 6

Semester: summer/winter

English Level: R2

Investigation of Thermal Processes in the IC Engine

Course Description:

Lectures and Seminars from the field of research and development of thermal processes in engines. The themes are: Research and analysis of theoretical cycles ,open and closed. Analysis of gas exchange processes (classical and advanced). Analysis of new combustion processes. Harmful emissions.

Lecturer: Assoc. Prof. Darko Kozarac

Literature:

1. Heywood J.B.: Internal Combustion Engine Fundamentals, McGraw – Hill, New York, 1988.
2. Ferguson C.R. and Kirkpatric A.T.: Internal combustion Engines, Wiley, New York, 2001.
3. Stone R.: Introduction to Internal Combustion Engines, Macmillan press Ltd., London, 1999.

ISVU Number: 156181

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Nonlinear Dynamics

Course Description:

Overview of nonlinear vibration systems with regard to the type of nonlinearities present in the system. Learning the phenomena that are characteristic for responses of non-linear vibration systems such as dependence of the natural frequency on vibration amplitude, the jump phenomenon, occurrence of superharmonics and subharmonics, limit cycles, dynamically stable and unstable solutions. Introduction to the most important methods for determining responses of nonlinear vibration systems (in the frequency and time domain) and the methods for determining the dynamic stability of the response.

Lecturer: Prof. Hinko Wolf, Asst. Prof. Neven Alujević

Literature:

1. P. S. Landa, Nonlinear Oscillations and Waves in Dynamical Systems, Kluwer Academic Publishers, 1996.
2. W. Szemplinska-Stupnicka, The Behavior of Nonlinear Vibrating Systems, Kluwer Academic Publishers, 1990
3. J. J. Thomsen, Vibrations and Stability, Springer, 2003.
4. G. Schmidt, A. Tondl, Non-Linear Vibrations, Cambridge University Press, Cambridge, London, New York, New Rochelle, Melbourne, Sydney, 1986.
5. A. H. Nayfeh, D. T. Mook, Nonlinear Oscillations, Wiley, 1995.

ISVU Number: 156122

ECTS Credits: 6

Semester: summer/winter

English Level: R1

Optical Methods of Mechanics

Course Description:

Learning the advanced optical methods of experimental mechanics for measuring of deformations and determination of stresses in deformable bodies. Practice in special methods of photoelasticity. Optical method of caustics, coherent gradient sensing (CGS) interpherometry, moire method, holographic interpherometry, speckle- interpherometry, thermoelastic stress analysis. Sterophotogrametry, object grating method and generating of cloud of points by 3D scanning. Measuring performed on characteristic examples that can be detected in real situation.

Lecturer: Prof. Damir Semenski

Literature:

1. Kobayashi, A. S., Handbook of Experimental Mechanics, New York, 1993.2. Rohrbach, C., Hanbuch fur experimentelle Spannunganalyse, VDI-Verlag,
2. Rohrbach, C., Hanbuch fur experimentelle Spannunganalyse, VDI-Verlag, Dusseldorf, 1989.
3. Kraus, K., Photogrammetry, Berlin, 2007.4. Alfirević, I.; Jecić, S., Fotelasticimetrija, Liber, Zagreb, 1983.
4. Alfirević, I.; Jecić, S., Fotelasticimetrija, Liber, Zagreb, 1983.
5. Papadopoulos, G. A., Fracture Mechanics, The Experimental Method of Caustics and the Det.-Criterion of Fracture, Springer-Verlag, 1993.

ISVU Number: 156105

ECTS Credits: 6

Semester: summer/winter

English Level: R2

Sliding-Rolling Contacts

Course Description:

The course examines theoretical and practical basis of sliding-rolling contacts of machine parts. Objective of the course is to get familiar with various contact types, with phenomena resulting from work of certain machine pairs, the most common failure scenarios and the development of underlying theories in the field and their application.

Lecturers: Assoc. Prof. Dragan Žeželj

Literature:

1. Williams, J.A.: Engineering Tribology, Oxford University Press Inc., 2000.
2. Stolarski, T.A.: Tribology in Machine Design, Butterworth-Heinemann, 2000.
3. Ivušić, V.: Tribologija, Hrvatsko društvo za materijale i tribologiju, Zagreb, 2002.

ISVU Number: 156053

ECTS Credits: 6

Semester: summer/winter

English Level: R2

Theory of Gearing

Course Description:

Geometry of spur and helical gears with involute external or internal teeth. Deep tooth profile gears. Thin rimmed gears. Calculation of surface durability (pitting), tooth bending strength and service life of spur and helical gears under variable loading. Maximum contact pressure and maximum toot root stress determination by means of finite element method. Gear testing methods. Experimental determination of deformations in tooth root using strain gauges and calculation of related stresses. Gear failure modes and analysis.

Lecturer:. Assoc. Prof. Krešimir Vučković

Literature:

1. Litvin, F., Fuentes, A.: Gear geometry and Applied Theory, Cambridge University Press, New York, 2004.
2. Flašker, J., Glodež, S., Ren, Z.: Zobniška gonila, Založba Pasadena, Maribor, 2008.
3. Opalić M.: Prijenosnici snage i gibanja, HDESK, Zagreb 1998.
4. Oberšmit, E.: Ozubljenja i zupčanici, SNL, Zagreb 1982.

ISVU Number: 156054

ECTS Credits: 6

Semester: summer/winter

English Level: R2

Theory of Plasticity

Course Description:

A theoretical bases of stress and strain analysis are extended by intoducing a material non-linearity. Influence of temperature and strain rate on plastic deformation processes of metals. Idealization of stretching diagrams and reological models, geometrical interpretation of plastic yielding conditions in stress space, and loading and unloading process. Yield surfaces of isotropic materials, strain-hardening of a material and Drucker's postulate. Constitutive equations of elastic-perfectly plastic materials. Tresca's and Mises' yield condition. Prandtl-Reuss' equations. Plastic potential and associated flow rule. Deformation theory of plasticity and flow theory. Basic incremental formulation of the finite element method for the analysis of elastic-plastic continuum. Limit structural analysis.

Lecturers: Prof. Jurica Sorić, Asst. Prof. Ivica Skozrit

Literature:

1. The Mathematical Theory of Plasticity, The Oxford engineering science series, Oxford at the Clarendon press, Oxford 1985.
2. Doltsinis, I., Elements of Plasticity-Theory and Computation, Wessex Institute of Technology Press, Southampton, Boston 2000.
3. Hosford, W. F., Mechanical Behavior of Materials, Cambridge University Press, New York 2005.

ISVU Number: 156112

ECTS Credits: 6

Semester: summer/winter

English Level: R3

Theory of Viscoelasticity

Course Description:

This course introduces the students to the theory of viscoelasticity, and it gives them the possibility to analyse stress and strain in the elements of engineering structures as a function of time. After the basic theory is adopted, the students will be able to perform creep and relaxation analysis in the mechanical structure using either analytical or numerical methods. Linear theory of viscoelasticity. Simple models of viscoelastic solid body. Maxwell´s model. Voight´s and Kelvin´s model. More complex models of viscoelastic solid body. Model of standard linear viscoelastic solid body. Multi-parameter viscoelastic models. Generalized Kelvin´s and Maxwell´s model. Creep and relaxation. Creep function and relaxation function. Differential constitutive equations. Application of Laplace transform. Application of the Finite Element Method in the Theory of Viscoelasticity. One-dimensional elastic-viscoplastic problems. Process of numerical computing and program´s structure. Two-dimensional elastic-viscoplastic problems. Numerical examples. Bars and thick-walled pressure vessels. Applied theory of viscoelasticity. Creep of bar subjected to bending and torsion. Relaxation of torsional moment in cross-sectional area of a bar. Creep and relaxation of the thick-walled pressure vessels.

Lecturer: Asst. Prof. Ivica Skozrit

Literature:

1. Alfirević, I. , Uvod u tenzore i mehaniku kontinuuma, Golden marketing, Zagreb 2003.
2. Hosford, W. F., Mechanical Behavior of Materials, Cambridge University Press, New York 2005.
3. Owen, D. R. J., Hinton, E., Finite Elements in Plasticity-Theory and Practice, Pineridge Press Limited, Swansea, United Kingdom, 1986.
4. Malinin, N. N. , Prikladnaja teorija plastičnosti i polzučesti, Mašinostroenie, Moskva 1975.
5. Ržanicin, A. R., Teorija puženja materijala, Građevinska knjiga, Beograd 1974.
6. Mase, G. E., Theory and Problems of Continuum Mechanics, Schaum´s Outline Series in Engineering, McGraw-Hill Book Company, New York, 1970.

ISVU Number: 156115

ECTS Credits: 6

Semester: summer/winter

English Level: R1

Vibrations of Systems with Clearances

Course Description:

Overview of the phenomena that is characteristic for responses of vibration systems with clearances (dependence of the natural frequency on vibration amplitude, the jump phenomenon, occurrence of super-harmonic and subharmonic resonances, dynamically stable and unstable solutions, bifurcations, chaos). Students will learn the most important methods for determining the response in the frequency and time domain (harmonic balance method, incremental harmonic balance method, Newton-Raphson incremental harmonic balance method, numerical simulations). Dynamic stability response determination by using Floquet- Lyapunov theorem will be introduced..

Lecturer: Assoc. Prof. Aleksandar Sušić

Literature:

1. W. Szemplinska-Stupnicka, The Behavior of Nonlinear Vibrating Systems, Kluwer Academic Publishers, 1990.
2. F. C. Moon, Chaotic and Fractal Dynamics, WILEY-VCH, 2004.
3. J. J. Thomsen, Vibrations and Stability, Springer, 2003.
4. G. Schmidt, A. Tondl, Non-Linear Vibrations, Cambridge University Press, Cambridge, London, New York, New Rochelle, Melbourne, Sydney, 1986.
5. A. H. Nayfeh, D. T. Mook, Nonlinear Oscillations, Wiley, 1995.
6. A. F. D'Souza, V. K. Garg, Advanced Dynamics Modeling and Analysis, Prentice-Hall, Inc., Englewood Cliffs, New Yersey 1984.

ISVU Number: 156123

ECTS Credits: 6

Semester: summer/winter

English Level: R1

Lecturers

Prof. Alar Vesna
- Corrosion Properties of Materials
- Corrosion Protection
- Failure Analysis

Assoc. Prof. Alar Željko
- Mechanical Properties of Materials
- Measuring of Force and Hardness

Prof. Emer. Alfirević Ivo
- Continuum Mechanics

Asst. Prof. Alujević Neven
- Dynamic of Machines
- Nonlinear Dynamics

Assoc. Prof. Andrić Jerolim
- Advanced Methods for Ship Structures Modelling and Analysis
- Feasibility and Reliability in Structural Design
- Multi-Criteria Optimization of Thin-Walled Structures

Prof. Barković Đuro
- Dimensional Measurements – Advanced Methods

Asst. Prof. Baršić Gorana
- Dimensional Nanometrology

Prof. Bauer Branko
- Advanced Procedures of Primary Shaping
- Simulation of Casting Processes

Assoc. Prof. Begić Hadžipašić Anita
- Corrosion of structural steels

Prof. Bojčetić Nenad
- Data Management in Product Development – PLM

Prof. Boras Ivanka
- Heat and Mass Transfer
- Advanced Quantitative Infrared Thermography

Prof. Bottasso Carlo
- Modelling, Control and Design of Wind Turbines

Prof. Božić Željko
- Fatigue and Fracture of Structures
- Mechanical Integrity of Structures

Assoc. Prof. Brezak Danko
- Machining Systems Monitoring and Control
- Advanced Computational Intelligence Systems
- Computational Intelligence Algorithms

Assoc. Prof. Brnardić Ivan
- Environmental Emissions from the Iron and Steel Metallurgy
- Wastes and By-products of the Metallurgical Industry

Asst. Prof. Cajner Hrvoje
- Design and Analysis of Experiments

Prof. Ciglar Damir
- Modelling and Simulation of Forming and Machining Processes
- High Efficiency Machining and Advanced Machine Tools
- Modern Machine Tools and Their Modules

Prof. Crneković Mladen
- Designing Mechatronic Systems
- Robotics
- Mobile Robots

Asst. Prof. Ćatipović Ivan
- Offshore Structure Loading
- Theory of Seakeeping and Manoeuvrability

Prof. Ćorić Danko
- Advanced Polymer Processing
- Functional Materials
- Mechanical Properties of Materials

Prof. Ćurković Lidija
- Materials Science and Engineering
- Engineering Ceramics
- Nanostructured Materials

Asst. Prof. Ćurković Petar
- Intelligent Production Processes

Prof. Degiuli Nastia
- Mathematical Methods in Marine Hydrodynamics
- CFD in Ship Design

Prof. Dejhajlla Roko
- CFD in Ship Design

Prof. Deur Joško
- Digital Control Systems
- Electrical Drives Control

Assoc. Prof. Dobrović Slaven
- Materials and Environment
- Energy and Environmental Protection

Assoc. Prof. Dolić Natalija
- Metallurgy of Aluminum

Prof. Dović Damir
- Experimental Methods in Heat and Mass Transfer
- Thermal Apparatus and Equipment

PhD Drvar Nenad
- Dimensional Measurements – Advanced Methods

Assoc. Prof. Dubreta Nikša
- Engineering Ethics and Social Responsibility

Prof. Duić Neven
- Introduction to scientific research
- Energy Planning Methods
- Modelling of Combustion and Radiative Heat Transfer
- Numerical Methods in Heat Transfer

Prof. Džijan Ivo
- Transients in Pipelines
- Computational Fluid Dynamics
- Transients in Pipelines

Prof. Đukić Goran
- Operations Research in Logistics

Asst. Prof. Ferdelji Nenad
- Heat and Mass Transfer
- Modelling and Approximation in Heat and Mass Transfer Processes

Prof. Emer. Franz Mladen
- Mechanical Properties of Materials

Assoc. Prof. Garašić Ivica
- Advanced Welding and Cutting Processes
- Robotization and Automation of Welding
- Underwater Welding and Cutting

Prof. Glavaš Zoran
- Solidification and As-cast Microstructure Evolution
- Innovative Processes of Metal Casting
- Metallurgy of Cast Irons and Steels

Assoc. Prof. Godec Damir
- Advanced Polymer Processing
- Micro and Nanotechnology
- Modern Additive Manufacturing of Products

Prof. Gojić Mirko
- Special Alloys
- Welding Metallurgy

Prof. Grgec Bermanec Lovorka
- Metrology of Heat and Process Quantities
- Methods for Estimating Measurement Uncertainty

Prof. Grilec Krešimir
- Materials Science and Engineering
- Cellular Materials
- Nanostructured Materials
- Tribology

Assoc. Prof. Grozdek Marino
- Storage of Thermal Energy in Buildings and Industry

Prof. Grubišić Luka
- Equations of Mathematical Physics

Prof. Guedes Soares Carlos
- Structual Safety

Prof. Guzović Zvonimir
- Methods for Useful Life Estimation of Power Equipment and Machines
- Selected Chapters from the Theory of Turbomachines
- The Flow, Thermal and Mechanical Phenomena in Turbomachines

Asst. Prof. Hadžić Neven
- Shipbuilding Management
- Shipbuilding Production Process Methods and Systems

Assoc. Prof. Haramina Tatjana
- Composite materials
- Polymer Materials

Asst. Prof. Hegedić Miro
- Operations and Project Management

Prof. Heinonen Heinonen Martti
- Advanced Thermal Measurements
- Mesuremnt and Calibration Systems

Asst. Prof. Hoić Matija
- Design of High Strength Joints

Assoc. Prof. Holjevac Grgurić Tamara
- Advanced Methods of Metal Research
- Phase Transformations in Metallic Materials

Prof. Hršak Damir
- Leaching Processes in Hydrometalurgy

Assoc. Prof. Jakovljević Suzana
- Cellular Materials
- Tribology
- Physical Principles of Metrological Instruments and Microscopy

Assoc. Prof. Jarak Tomislav
- Advanced Methods of Numerical Analysis of Structures

Prof. Jasak Hrvoje
- Computational Aerodynamics
- Numerical Simulations in Energy Conversion Processes
- The Flow, Thermal and Mechanical Phenomena in Turbomachines

Prof. Jerbić Bojan
- Designing Mechatronic Systems
- Robotics
- Learning Methods and Programming of Autonomous Robotic Systems

Assoc. Prof. Jokić Andrej
- Distributed Control Systems
- Optimization Techniques in Control
- Advanced Control for Energy Efficiency and Demand Response in Smart Grids

Asst. Prof. Jokić Marko
- Structural Computational Dynamics

Prof. Jurčević Lulić Tanja
- Biomechanics

Assoc. Prof. Juretić Hrvoje
- Energy and Environmental Protection

Assoc. Prof. Karšaj Igor
- Continuum Mechanics
- Computational Biomechanics

Prof. Kasać Josip
- Methods of Automatization
- Distributed Control Systems
- Nonlinear Control Systems

Asst. Prof. Katić Marko
- Fundamental Metrology
- Dimensional Measurements – Advanced Methods

Asst. Prof. Keran Zdenka
- Advanced Forming Processes
- Numerical Simulation of Metal Forming

Assoc. Prof. Kozarac Darko
- Computationally Supported Development of the ICE and Vehicles
- Investigation of Thermal Processes in the IC Engine

Prof. Kozmar Hrvoje
- Environmental Aerodynamics
- Wind and Structures

Prof. Kožuh Stjepan
- Advanced Physical Metallurgy
- Phase Transformations in Metallic Materials
- Welding Metallurgy

Prof. Kožuh Zoran
- Advanced Welding and Cutting Processes
- Adhesive Bonding in Fabrication
- Robotization and Automation of Welding

Assoc. Prof. Krajačić Goran
- Energy Planning Methods

Prof. Kunica Zoran
- Intelligent Production Processes

Prof. Landek Darko
- Heat Treatment and Surface Engineering
- Modeling in Materials Research
- Advanced Tool Materials
- Thermodynamic and Structure of Materials

Prof. Lazić Ladislav
- Energy Efficiency of Industrial Furnaces
- Mathematical Modelling of Industrial Furnaces

Prof. Lisjak Dragutin
- Intelligent Information Systems
- Maintenance Management

Prof. Lončar Dražen
- Dynamics and Control of Thermo-Hydraulic Processes

Asst. Prof. Lovrenić Jugović Martina
- Theory of Metal Forming Process
- Mathematical Modelling of Industrial Furnaces

Prof. Lulić Zoran
- Alternative Drives of Motor Vehicles
- Engines and Vehicles – Selected Topics

Prof. Lund Henrik
- Energy Planning Methods

Prof. Ljubas Davor
- Energy and Environmental Protection

Prof. Majetić Dubravko
- Introduction to scientific research
- Computational Intelligence Algorithms
- Nanorobotics
- Advanced Computational Intelligence Systems

PhD Malenica Šime
- Mathematical Methods in Marine Hydrodynamics
- Hydroelasticity of Ships and Marine Structures

Prof. Markučič Damir
- Nondestructive Evaluation Methods

Prof. Masarati Pierangelo
- Rotary Wing Aeroelasticity

Prof. Matijević Božidar
- Heat Treatment and Surface Engineering
- Advanced Tool Materials
- Thermodynamic and Structure of Materials

Prof. Medved Jožef
- Theory of Metallurgical Processes

Asst. Prof. Milić Vladimir
- Scientific Cloud Computing

Prof. Mrvar Primož
- Solidification and As-cast Microstructure Evolution
- Innovative Processes of Metal Casting

Asst. Prof. Mudrinić Saša
- Heat and Mass Transfer

Prof. Emer. Novaković Branko
- Methods of Automatization
- Nanorobotics
- Nonlinear Control Systems

Asst. Prof. Opetuk Tihomir
- Intelligent Process Planning
- Sustainable Production

Prof. Parunov Joško
- Introduction to scientific research
- Advanced Methods of Fatigue Assessment of Welded Ship Structures
- Stochastic Modelling of Loads of Ship Structures

Assoc. Prof. Pavković Danijel
- Digital Control Systems
- Electrical Drives Control
- Selected Topics of Computer Control
- Sensorics

Prof. Pavković Neven
- Data Management in Product Development – PLM
- Design Theories

Assoc. Prof. Pezer Robert
- Advanced Physical Metallurgy

Assoc. Prof. Prebeg Pero
- Multi-Criteria Optimization of Thin-Walled Structures

Prof. Rede Vera
- Advanced Metal Construction Materials
- Materials Selection and Product Development
- Methods of Materials Characterization

Prof. Rešković Stoja
- Theory of Metal Forming Process
- Deformation Properties of Metals and Alloys

Prof. Rudan Smiljko
- Advanced Methods for Ship Structures Modelling and Analysis
- Ships Collisions and Groundings

Prof. Runje Biserka
- Quality Management
- Advanced Statistical Methods in Metrology
- Methods for Estimating Measurement Uncertainty

Prof. Schauperl Zdravko
- Composite materials
- Methods of Materials Characterization

Prof. Schneider Daniel Rolph
- Development of Modern Thermal Power Plants
- Modelling of Combustion and Radiative Heat Transfer

Prof. Semenski Damir
- Theory of Elasticity
- Optical Methods of Mechanics

Prof. Emer. Senjanović Ivo
- Hydroelasticity of Ships and Marine Structures

Prof. Singer Sanja
- Numerical Linear Algebra

Asst. Prof. Skozrit Ivica
- Theory of Plasticity
- Theory of Viscoelasticity

Assoc. Prof. Slapničar Vedran
- Probabilistic Approach to Damage Stability
- Profitable Ship Design

Assoc. Prof. Slokar Benić Ljerka
- Advanced Physical Metallurgy
- Advanced Methods of Metal Research
- Special Alloys

Prof. Smojver Ivica
- Mechanics of Composite Structures
- Selected Topics of Strength of Aeronautical Structures

Prof. Soldo Vladimir
- Cooling-Heating Processes with Heat Pumps

Prof. Sorić Jurica
- Advanced Methods of Numerical Analysis of Structures
- Modelling from Macro- to NanoScale
- Numerical Methods of Nonlinear Analysis of Structures
- Theory of Plasticity

Asst. Prof. Staroveški Tomislav
- Recent trends in machining technologies

Prof. Stepanić Josip
- Physical Principles of Metrological Instruments and Microscopy

Asst. Prof. Stipančić Tomislav
- Intelligent Production Processes
- Scientific Cloud Computing

Asst. Prof. Stojanović Ivan
- Failure Analysis

Assoc. Prof. Sušić Aleksandar
- Vibrations of Systems with Clearances

Prof. Šavar Mario
- Transport Phenomena
- Heat and Mass Transfer
- Transients in Pipelines

Prof. Šercer Mladen
- Advanced Procedures of Primary Shaping
- Advanced Polymer Processing
- Micro and Nanotechnology

Asst. Prof. Šimunović Vinko
- Corrosion Properties of Materials

Prof. Šitum Željko
- Hydraulics and Pneumatics – Selected Topics
- Pneumatic and Hydraulic Servo Systems

Asst. Prof. Škec Stanko
- Complex Socio-Technical Systems

Prof. Štefanić Nedeljko
- Operations and Project Management

Prof. Štorga Mario
- Complex Socio-Technical Systems
- Design Theories

Assoc. Prof. Štrkalj Anita
- Modern Methods of Chemical Analysis in Metallurgy

Prof. Terze Zdravko
- Introduction to scientific research
- Geometric Mechanics
- Modelling, Control and Design of Wind Turbines
- Rotary Wing Aeroelasticity

Asst. Prof. Tomičević Zvonimir
- Experimental Model Techniques
- Effects of In-built Material Properties ona As-built Ships

Prof. Tonković Zdenko
- Fracture Mechanics, Damage and Fatigue
- Modelling from Macro- to NanoScale
- Numerical Methods of Nonlinear Analysis of Structures

Prof. Tuković Željko
- Computational Aerodynamics
- Numerical Simulations in Energy Conversion Processes
- Selected Chapters from the Theory of Turbomachines

Prof. Udiljak Toma
- Modelling and Simulation of Forming and Machining Processes
- Automated Machining Systems
- High Efficiency Machining and Advanced Machine Tools

Prof. Virag Zdravko
- Biological Flows
- Heat and Mass Transfer
- Computational Fluid Dynamics

Asst. Prof. Vladimir Nikola
- Design of Marine Propulsion Systems
- Ship Propulsion System Vibrations

Prof. Vrdoljak Milan
- Modelling, Simulation and Control of Flying Objects
- Rotor Aerodynamics

Assoc. Prof. Vučković Krešimir
- Theory of Gearing

Asst. Prof. Vujanović Milan
- Modelling of Combustion and Radiative Heat Transfer
- Numerical Methods in Heat Transfer

Prof. Wolf Hinko
- Dynamic of Machines
- Nonlinear Dynamics

Prof. Zorc Davor
- Selected Topics of Computer Control
- Sensorics

Assoc. Prof. Zovko Brodarac Zdenka
- Solidification and As-cast Microstructure Evolution
- Aluminum Alloy Casting
- Innovative Processes of Metal Casting

Prof. Zvizdić Davor
- Advanced Thermal Measurements
- Mesuremnt and Calibration Systems
- Metrology of Heat and Process Quantities
- Fundamental Metrology

Asst. Prof. Žakula Tea
- Advanced Control for Energy Efficiency and Demand Response in Smart Grids
- Modelling and Approximation in Heat and Mass Transfer Processes

Assoc. Prof. Žeželj Dragan
- Sliding-Rolling Contacts

Prof. Emer. Žiha Kalman
- Effects of In-built Material Properties on As-built Ships
- Simulation and Analytic Methods in Reliability of Marine Objects

Assoc. Prof. Žmak Irena
- Modeling in Materials Research
- Materials and Environment
- Materials Selection and Product Development