University of Rijeka
Faculty of Engineering

# CURRICULUM
# GRADUATE UNIVERSITY STUDY OF ELECTRICAL ENGINEERING

Rijeka, April 2021

# 1. CURRICULUM DESCRIPTION

## 1.1. The list of compulsory and elective courses with the number of active classes required for their performance and ECTS credits

| 1. semester | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Subject title | Hours / week | | | | | ECTS |
| | | L | aT | lT | dT | L+T | |
| | Numerical and Stochastic Mathematics | 3 | | 1 | | 4 | 6 |
| | Control of Electrical Drives | 3 | | 1 | | 4 | 6 |
| **Subjects from elective group Automation:** | | | | | | | |
| | Fundamentals of Robotics | 3 | | 1 | | 4 | 6 |
| | Digital Signal Processing | 3 | 1 | | | 4 | 6 |
| | Microwave Engineering | 3 | 1 | | | 4 | 6 |
| **Subjects from elective group Power Engineering:** | | | | | | | |
| | Electromagnetics | 3 | 1 | 1 | | 5 | 6 |
| | Transmission and Distribution of Electrical Energy | 3 | 1 | | 1 | 5 | 6 |
| | Driving and Operating Engines | 3 | 1 | | | 4 | 6 |
| | **TOTAL** | | | | | **22** | **30** |

L - lectures, aT – auditory tutorials, lT – laboratory tutorials, dT – design tutorials.

| 2. semester | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Subject title | Hours / week | | | | | ECTS |
| | | L | aT | lT | dT | L+T | |
| | Project I[1] | | | | 2 | 2 | 5 |
| | Free Elective Subject I[2] | | | | | | 5 |
| | Professional Practice II | | | | | | 5 |
| **Subjects from elective group Automation:** | | | | | | | |
| | Digital Control Systems | 2 | 1 | 1 | | 4 | 5 |
| | Analog Signal Processing | 2 | | 2 | | 4 | 5 |
| | Automated Instrumentation | 2 | | 2 | | 4 | 5 |
| **Subjects from elective group Power Engineering:** | | | | | | | |
| | Electric Power Plants | 3 | 1 | | | 4 | 5 |
| | Electric Power Substation Design | 3 | 1 | 1 | | 5 | 5 |
| | High Voltage Engineering | 2 | 2 | | | 4 | 5 |
| | **TOTAL** | | | | | **19** | **30** |

[1] Enroll one subject.

[2] Enroll one subject in the 2nd semester from other elective groups or from other graduate studies at the Faculty of Engineering University of Rijeka, worth 5 ECTS or more.

**Subjects from which can be enrolled Project I according to the elective groups:**
**Elective group Automation:** Automated Instrumentation, Control of Electrical Drives, Digital Signal Processing, Fundamentals of Robotics, Microwave Engineering
**Elective group Power Engineering:** Electric Power Plants, Electric Power Substation Design, Electromagnetics, High Voltage Engineering, Transmission and Distribution of Electrical Energy

| 3. semester | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Subject title | Hours / week | | | | | ECTS |
| | | L | aT | lT | dT | L+T | |
| | Project II[3] | | | | 2 | 2 | 5 |
| | Elective Subject I | | | | | | 5 |
| | Free Elective Subject II[4] | | | | | | 5 |
| **Subjects from elective group Automation:** | | | | | | | |
| | Mechatronic Systems | 2 | 1 | 1 | | 4 | 5 |
| | Automation of Plants and Processes | 2 | | 2 | | 4 | 5 |
| | Statistical Signal Analysis | 3 | 1 | | | 4 | 6 |
| **Subjects from elective group Power Engineering:** | | | | | | | |
| | Electric Power Systems | 2 | 1 | | 1 | 4 | 6 |
| | Protection and Automation of Electrical Installations | 2 | 1 | 1 | 1 | 5 | 5 |
| | Electric Power System Management | 2 | 1 | 1 | | 4 | 5 |
| | **TOTAL** | | | | | **23** | **30** |

[3] Enroll one subject.

[4] Enroll one subject in the 3rd semester from other elective groups or from other graduate studies at the Faculty of Engineering University of Rijeka, worth 5 ECTS or more.

**Subjects from which can be enrolled Project II according to the elective groups:**
**Elective group Automation:** Analog Signal Processing, Assistive Technology, Automated Instrumentation, Automation of Plants and Processes, Digital Control Systems, Digital Signal Processing, Fundamentals of Robotics, Mechatronic Systems, Optoelectronics, Microwave Engineering

**Elective group Power Engineering:** Electric Power Plants, Electric Power Systems, Electric Power System Management, Electric Power Substation Design, High Voltage Engineering, Protection and Automation of Electrical Installations, Electromagnetics, Transmission and Distribution of Electrical Energy

| Elective Subject I | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Subject title | Hours / week | | | | | ECTS |
| | | L | aT | lT | dT | L+T | |
| **Subjects from elective group Automation:** | | | | | | | |
| | Optoelectronics | 2 | 1 | | | 3 | 4 |
| | Assistive Technology | 2 | | | 2 | 4 | 6 |
| **Subjects from elective group Power Engineering:** | | | | | | | |
| | Optoelectronics | 2 | 1 | | | 3 | 4 |
| | Power Plants | 2 | 2 | | | 4 | 4 |

| 4. semester | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Subject title | Hours / week | | | | | ECTS |
| | | L | aT | lT | dT | L+T | |
| | Free Elective Subject III[5]<br>Graduate Work | | | | | 4 | 5<br>10 |
| **Subjects from elective group Automation:** | | | | | | | |
| | Evolutionary Robotics<br>Elective Subject II<br>Elective Subject III | 2 | 1 | 1 | | 4 | 5<br>5<br>5 |
| **Subjects from elective group Power Engineering:** | | | | | | | |
| | Electricity Market<br>Elective Subject II<br>Elective Subject III | 2 | 2 | | | 4 | 5<br>5<br>5 |
| | **TOTAL** | | | | | **16** | **30** |

[5] Enroll one subject in the 4th semester from other elective groups or from other graduate studies at the Faculty of Engineering University of Rijeka, worth 5 ECTS or more.

| Elective Subjects | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Subject title | Hours / week | | | | | ECTS |
| | | L | aT | lT | dT | L+T | |
| **Subjects from elective group Automation:** | | | | | | | |
| | Digital Image Processing | 2 | 2 | | | 4 | 6 |
| | Man Machine Communication | 2 | 2 | | | 4 | 5 |
| | Application of Artificial Intelligence | 2 | | 1 | | 3 | 5 |
| | Urban Energy Systems | 2 | 2 | | | 4 | 5 |
| **Subjects from elective group Power Engineering:** | | | | | | | |
| | Digital Image Processing | 2 | 2 | | | 4 | 6 |
| | Man Machine Communication | 2 | 2 | | | 4 | 5 |
| | Application of Artificial Intelligence | 2 | | 1 | | 3 | 5 |
| | Urban Energy Systems | 2 | 2 | | | 4 | 5 |

| GRADUATE UNIVERSITY STUDY OF ELECTRICAL ENGINEERING TOTAL | Hours | ECTS |
|---|---|---|
| | **80** | **120** |

| Basic description | | |
|---|---|---|
| Course title | **Analog Signal Processing** | |
| Study programme | **Graduate University Study of Electrical Engineering** | |
| Course status | optional | |
| Year | **1.** | |
| ECTS credits and teaching | ECTS student 's workload coefficient | 5 |
| | Number of hours (L+E+S) | 30+30+0 |

| 1. COURSE DESCRIPTION | | |
|---|---|---|
| *1.1. Course objectives* | | |
| Understanding of relationship between signals in time domain and frequency domain. Ability of solving problems in order to design electrical filters which fulfill given specifications. From basic competencies ability of analysis and synthesis, team work and basic computing skils with problem solvings will be developed. | | |
| *1.2. Course enrolment requirements* | | |
| None. | | |
| *1.3. Expected course learning outcomes* | | |
| After passing of exam, student is able to do following:<br>Distinguish signals in time and frequency domain. Apply basic mathematical operations on time domain signals. Apply Fourier transform and inverse Fourier transform. Valorize linear systems and idealized systems. Valorize and compare given filter transfer function approximations. Describe filter realizations designed with operational and transconductance amplifiers. Analyse high-order filter structures. Make the first and the second order filter design using operational and transconductance amplifiers based on given specifications. Make high-order filter cascade realization using operational and transconductance amplifiers based on given specifications. Valorize sensitivity measures of electrical filters. | | |
| *1.4. Course content* | | |
| Signals in time and frequency domain. Operation over signals. Operational amplifier, ideal and real. Fourier transform in signal processing. Signal spectrum. Frequency analysis and responses. Signal filtering and filter classification. Filter characteristics: amplitude and phase. Group time delay. Filter transfer function. Approximation of filter responses with rational functions. Approximation types: Butterworth, Chebyshev, Bessel, Cauer. Passive realizations. Active realizations. The first and the second order filter blocks. High-order filter realizations. Active filter structures. Sensitivity. Influence of real parameters. | | |
| *1.5. Teaching methods* | ☒ lectures<br>☐ seminars and workshops<br>☒ exercises<br>☐ long distance education<br>☐ fieldwork | ☒ individual assignment<br>☒ multimedia and network<br>☒ laboratories<br>☐ mentorship<br>☐ other |
| *1.6. Comments* | | |
| *1.7. Student's obligations* | | |
| Course attendance, homework, laboratory work, written exam. | | |
| *1.8. Evaluation of student's work* | | |

| Course attendance | 2 | Activity/Participation | | Seminar paper | | Experimental work | |
|---|---|---|---|---|---|---|---|

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Written exam | 1 | Oral exam | | Essay | | Research | |
| Project | 0.5 | Sustained knowledge check | 1.5 | Report | | Practice | |
| Portfolio | | | | | | | |

*1.9. Procedure and examples of learning outcome assessment in class and at the final exam*

Course attendance, homework, laboratory work, continuous knowledge testing, written exam.

*1.10. Assigned reading (at the time of the submission of study programme proposal)*

N. Stojković, N. Mijat: Analog Signal Processing, Tehnički fakultet, Rijeka, 2005. (in Croatian)
Z. Šverko, N. Stojković, M. Stojković: Analog Signal Processing – students handbook, Tehnički fakultet, Rijeka, 2021. (in Croatian)

*1.11. Optional / additional reading (at the time of proposing study programme)*

N. Stojković, V. Naglić, N. Mijat: Theory of networks and transmission lines, Tehnički fakultet, Rijeka, 2005. (in Croatian)

*1.12. Number of assigned reading copies with regard to the number of students currently attending the course*

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| N. Stojković, N. Mijat: Analog Signal Processing, Tehnički fakultet, Rijeka, 2005. (in Croatian) | 6 | 40 |
| Z. Šverko, N. Stojković, M. Stojković: Analog Signal Processing – students handbook, Tehnički fakultet, Rijeka, 2021. (in Croatian) | *e*-edition | 40 |
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| | | |

*1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences*

Through the Institution’s quality assurance system.

| Basic description | | |
|---|---|---|
| Course title | **Application of Artificial Intelligence** | |
| Study programme | **Graduate University Study of Electrical Engineering** | |
| Course status | optional | |
| Year | **2.** | |
| ECTS credits and teaching | ECTS student 's workload coefficient | 5 |
| | Number of hours (L+E+S) | 30+15+0 |

| **1.COURSE DESCRIPTION** | | |
|---|---|---|
| *1.1. Course objectives* | | |
| Acquisition of theoretical and practical knowledge on the application of advanced algorithms in complex systems | | |
| *1.2. Course enrolment requirements* | | |
| None. | | |
| *1.3. Expected course learning outcomes* | | |
| Define the term artificial intelligence. Analyze the problem-solving methodology. Explain knowledge-based information system. Define and analyze an artificial neural network. Identify and analyze the techniques of evolutionary computation. Define and analyze machine learning algorithms. Identify and analyze the theory of games. Apply artificial intelligence in optimization problems. Analyze systems of learning and visual recognition. Apple autonomous agents with collaborative behavior. Applied game theory in economic systems. Apply artificial intelligence to simulate a social system. | | |
| *1.4. Course content* | | |
| Definition of artificial intelligence. A historical overview and a look into the future. Problem solving methodology. Knowledge and reasoning: knowledge-based information system. Unreliability of knowledge and reasoning. Artificial neural networks. Convolutional neural networks. Evolutionary computation: genetic algorithms, fuzzy logic. Particle swarm optimization and artificial bee colony. Support vector method and k-nearest algorithm neighbors. Expert systems. Machine learning: learning from perception, learning in neural and belief networks, learning on mistakes, knowledge in learning. Game theory: complex multi-agent systems, autonomous intelligent agents. Data mining. Application of artificial intelligence, optimization and planning of real problems, learning systems, visual recognition systems, artificial intelligent systems in robotics, autonomous agents with collaborative behavior, game theory in economic systems, application of artificial intelligence algorithms in medicine, language processing and recognition, social simulation. Automated devices. Driven tools. | | |
| *1.5. Teaching methods* | ☒ lectures<br>☐ seminars and workshops<br>☒ exercises<br>☐ long distance education<br>☐ fieldwork | ☒ individual assignment<br>☐ multimedia and network<br>☐ laboratories<br>☐ mentorship<br>☐ other |
| *1.6. Comments* | | |
| *1.7. Student's obligations* | | |
| Attendance, activities in the classroom, homework and self-study. | | |
| *1.8. Evaluation of student's work* | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 1.5 | Activity/Participation | | Seminar paper | | Experimental work | |
| Written exam | 1 | Oral exam | 1 | Essay | | Research | |
| Project | 1 | Sustained knowledge check | | Report | | Practice | 0.5 |
| Portfolio | | | | | | | |

*1.9. Procedure and examples of learning outcome assessment in class and at the final exam*

Oral explanation of simulation exercises or project task, continuous knowledge test (two control tasks), written final and oral exam.

*1.10. Assigned reading (at the time of the submission of study programme proposal)*

Bramer, M., Devedzic, l, Artificial Intelligence application and Innovations, 2004.
Arbir, M.A.,The Handbook of Brain Theory and Neural Networks, 2002.
Russell, S.J., Norvig P., Artificial Intelligence: A Modern Approach, 2009.
Understanding Artificial Intelligence (Science Made Accessible), 2002.
George F. Luger. Artificial Intelligence: Structures and Strategies for Complex Problem Solving. Addison-Wesley, 2005

*1.11. Optional / additional reading (at the time of proposing study programme)*

Ritter, G.X., Wilson, J.N., Handbook of Computer Vision Algorithms in Image Algebra, 1996.
Thalmann, N.M., Thalmann, D., Artificial Life and Virtual Reality, 1994.
Blay Whitby. Artificial Intelligence. Oneworld Publications, 2003.

*1.12. Number of assigned reading copies with regard to the number of students currently attending the course*

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| Bramer, M., Devedzic, l, Artificial Intelligence application and Innovations, 2004. | | |
| Arbir, M.A.,The Handbook of Brain Theory and Neural Networks, 2002. | 1 | |
| Russell, S.J., Norvig P., Artificial Intelligence: A Modern Approach, 2009. | 1 | |
| Understanding Artificial Intelligence (Science Made Accessible), 2002. | | |
| | | |

*1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences*

Through a structured quality assurance system of the Faculty.

| Basic description | | |
|---|---|---|
| Course title | **Assistive Technology** | |
| Study programme | **Graduate University Study of Electrical Engineering** | |
| Course status | optional | |
| Year | 2. | |
| ECTS credits and teaching | ECTS student's workload coefficient | 6 |
| | Number of hours (L+E+S) | 30+30+0 |

| 1. **COURSE DESCRIPTION** | | |
|---|---|---|
| *1.1. Course objectives* | | |
| Main goal of the course is to gain skills and practical and theoretical knowledge for the development and implementation of assistive technology systems and devices. | | |
| *1.2. Course enrolment requirements* | | |
| None. | | |
| *1.3. Expected course learning outcomes* | | |
| Analyze the needs of individuals with disability for assistive technology. Describe user interfaces which are adapted to individuals with disability. Describe voice interactive systems. Analyze the deployment of assistive robotics. | | |
| *1.4. Course content* | | |
| Overview of tehnology for individuals with disability. Computer applications and user interfaces for individuals with disability. Voice interactive systems. Home automation. Ambient intelligence. Design for all. Assitive robotics. Mobility of a disabled person. | | |
| *1.5. Teaching methods* | ☒ lectures<br>☐ seminars and workshops<br>☒ exercises<br>☐ long distance education<br>☐ fieldwork | ☒ individual assignment<br>☒ multimedia and network<br>☒ laboratories<br>☐ mentorship<br>☐ other |
| *1.6. Comments* | | |
| *1.7. Student's obligations* | | |
| Class attendance, tests, and labs. | | |
| *1.8. Evaluation of student's work* | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 2 | Activity/Participation | | Seminar paper | | Experimental work | |
| Written exam | 1 | Oral exam | | Essay | | Research | 1 |
| Project | 1 | Sustained knowledge check | | Report | | Practice | 1 |
| Portfolio | | | | | | | |

| *1.9. Procedure and examples of learning outcome assessment in class and at the final exam* |
|---|
| Lectures and tutorials attendance, project presentation, and final exam. |

| | |
|---|---|
| *1.10.* | *Assigned reading (at the time of the submission of study programme proposal)* |
| | |
| *1.11.* | *Optional / additional reading (at the time of proposing study programme)* |

Helal, A. et al. (2008). The Engineering Handbook of Smart Technology for Aging, Disability and Independence, Wiley-Interscience, Hoboken, New Yersey.
Scherer, M. (2005). Living in the State of Stuck: How Assistive Technology Impacts the Lives of People with Disabilities. Brookline Books.
Mann, C. (2005). Smart Technology for Aging, Disability, and Independence: The State of the Science. Wiley-Interscience.
De Jonge, D. et al. (2006). Assistive Technology in the Workplace. Mosby.
Burdick, D. et al. (2004). Gerotechnology: Research and Practice in Technology and Aging, Springer.

*1.12. Number of assigned reading copies with regard to the number of students currently attending the course*

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| Helal, A. et al. (2008). The Engineering Handbook of Smart Technology for Aging, Disability and Independence, Wiley-Interscience, Hoboken, New Yersey. | 1 | 10 |
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*1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences*

Through the quality assurance system of the Faculty of Engineering.

| Basic description | | | |
|---|---|---|---|
| Course title | **Automated Instrumentation** | | |
| Study programme | **Graduate University Study of Electrical Engineering** | | |
| Course status | optional | | |
| Year | **1.** | | |
| ECTS credits and teaching | ECTS student 's workload coefficient | 5 | |
| | Number of hours (L+E+S) | 30+30+0 | |

| 1. COURSE DESCRIPTION | | |
|---|---|---|
| *1.1. Course objectives* | | |
| Automated instrumentation introduces students with advantages, possibilities and realization of automated instrumentation. | | |
| *1.2. Course enrolment requirements* | | |
| None. | | |
| *1.3. Expected course learning outcomes* | | |
| After passing the exam, student is able to do following:<br>1. Describe static and dynamic errors of operational amplifiers<br>2. Analyze measurement amplifiers<br>3. Describe transfer function of A/D and D/A converters<br>4. Describe working principles of different types of A/D converters<br>5. Select the appropriate type of A/D converter for different measurement problems.<br>6. Describe the working principles of signal sources and user interfaces<br>7. Implement virtual instrument<br>8. Analyze characteristics of automated instrumentation | | |
| *1.4. Course content* | | |
| Measurement systems. Automated instrumentation. Advantages, possibilities and future. Analog signal processing. Limitations of operational amplifiers. Application of high degree integration electronics. Analog-digital converters. Effective number of bits and effective bandwidth as a source of error. Programmable instrumentation. Waveform analyzers. Signal sources. User interfaces. Achieving desired accuracy. Self calibration. Microprocessors and microcontrollers in computerized instrumentation. Principles and criteria for microprocessor-driven instrumentation. Communication with measurement equipment. Basic configurations of computerized measurement systems. Virtual instrumentation. Automated test systems. Examples of implementations. | | |
| *1.5. Teaching methods* | ☒ lectures<br>☐ seminars and workshops<br>☒ exercises<br>☐ long distance education<br>☐ fieldwork | ☒ individual assignment<br>☐ multimedia and network<br>☒ laboratories<br>☐ mentorship<br>☐ other |
| *1.6. Comments* | | |
| *1.7. Student's obligations* | | |
| Course and laboratory practice attendance, seminar paper, activity during course lectures, studying. | | |
| *1.8. Evaluation of student's work* | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 2 | Activity/Participation | | Seminar paper | 1 | Experimental work | |
| Written exam | | Oral exam | | Essay | | Research | |
| Project | | Sustained knowledge check | 1 | Report | | Practice | 1 |
| Portfolio | | Homework | | | | | |

*1.9. Procedure and examples of learning outcome assessment in class and at the final exam*

Assessment and evaluation of student's work will be based on sustained knowledge checks, laboratory practice and based on seminar paper and/or final exam.

*1.10. Assigned reading (at the time of the submission of study programme proposal)*

Šantić, A.: Electronic Instrumentation, 3rd Edition, Školska knjiga, Zagreb, 1993. (in Croatian)
Franco, S.: Design with Operational Amplifiers and Analog Integrated Circuits, 3rd Edition, McGraw-Hill, 2002.

*1.11. Optional / additional reading (at the time of proposing study programme)*

Fowler, K.R.: Electronic Instrument Design, Architecting for the life cycle, Oxford University Press, 1996.
Coombs, C.F.Jr.: Electronic Instrument Handbook, McGraw-Hill, 2nd Edition, 1999.
Derenzo, S.E.: Practical Interfacing in the Laboratory, Cambridge University Press, 2003.

*1.12. Number of assigned reading copies with regard to the number of students currently attending the course*

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| Šantić, A.: Electronic Instrumentation, 3rd Edition, Školska knjiga, Zagreb, 1993. (in Croatian) | 8 | 40 |
| Franco, S.: Design with Operational Amplifiers and Analog Integrated Circuits, 3rd Edition, McGraw-Hill, 2002. | 1 | 40 |
| | | |
| | | |
| | | |

*1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences*

Through the Institution's quality assurance system.

| Basic description | | | |
|---|---|---|---|
| Course title | **Automation of Plants and Processes** | | |
| Study programme | **Graduate University Study of Electrical Engineering** | | |
| Course status | optional | | |
| Year | **2.** | | |
| ECTS credits and teaching | ECTS student 's workload coefficient | 5 | |
| | Number of hours (L+E+S) | 30+30+0 | |

| 1. **COURSE DESCRIPTION** | | |
|---|---|---|
| *1.1. Course objectives* | | |
| Understanding the theoretical principles and practical knowledge to solve problems in scope of automation of plants and processes, methods to analyse and synthetize control systems and design the automation systems. Understanding the operation of programmable logic controller Siemens STEP 7 for automation of complex systems models. | | |
| *1.2. Course enrolment requirements* | | |
| None. | | |
| *1.3. Expected course learning outcomes* | | |
| Describing the role of plants and processes automation. Describing the structures of automation, process peripherals and process computer interface. Describing the basic approaches to increase the system reliability. Defining the principles of processes dynamics. Applying the equilibrium equations to modelling of process plants. Defining the basic properties of coupled processes. Applying the methods to decoupling of coupled processes. Utilizing the theoretical knowledge in design and realisation of automation system. Synthetizing the control circuits by taking into the account the implementation aspects of control circuit elements. Designing the controllers for systems with significant dead time. Understanding the operation principles and programing of programmable logic controllers. | | |
| *1.4. Course content* | | |
| Introduction to processes automation. Levels of process management and automation functions. Example of system process automation. Structures of automation systems: centralized and decentralized structures. Distributed automation systems, automation structures with redundancy. Process peripherals. Digital and analog input/output units. Reliability and security of process automation systems. Introduction to process dynamics. Introduction to heat processes dynamics. Basic principles. Heat exchangers. Modelling and control of multiple-input multiple-output coupled processes. Decoupling control. Implementations and applications of PID controllers. Sampling time selection. Practical methods for controller parameters tuning: Takahashi method and relay based method. Process mathematical model based controllers: IMC control, Smith predictor based controller, compensation controllers. Pump station automation using the PLC. Realisation of supervisory-control system (SCADA). Experimental tuning of the PID controller on system model. | | |
| *1.5. Teaching methods* | ☒ lectures<br>☐ seminars and workshops<br>☒ exercises<br>☐ long distance education<br>☐ fieldwork | ☐ individual assignment<br>☐ multimedia and network<br>☒ laboratories<br>☐ mentorship<br>☐ other |
| *1.6. Comments* | - | |
| *1.7. Student's obligations* | | |

| |
|---|
| Course attendance, activity, laboratory exercises, individual studying. |
| *1.8. Evaluation of student's work* |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 2 | Activity/Participation | | Seminar paper | | Experimental work | |
| Written exam | 1 | Oral exam | | Essay | | Research | |
| Project | | Sustained knowledge check | 1 | Report | | Practice | 1 |
| Portfolio | | | | | | | |

| |
|---|
| *1.9. Assessment and evaluation of student's work during classes and on final exam* |
| Course attendance, activity, laboratory exercises, sustained knowledge check (two tests for laboratory tutorials and two tests for auditory tutorials), written exam. |
| *1.10. Assigned reading (at the time of the submission of study programme proposal)* |
| N. Perić, I. Petrović: Automation of Plants and Processes - lectures, Script by Department for APR, FER, Zagreb, 2000. (in Croatian) |
| *1.11. Optional / additional reading (at the time of proposing study programme)* |
| D.E.Seborg, T.F. Edgar, D.A. Mellichamp: Process Dynamics and Control, John Wiley&Sons, New York, 1989.<br>Siemens Manual for SIMATIC PLC and WinCC SCADA Systems (available on the course web site) |
| *1.12. Number of assigned reading copies with regard to the number of students currently attending the course* |

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| Automation of Plants and Processes – lectures (script available for copying in first week of teaching) (in Croatian) | | 30 |
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|---|
| *1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences* |
| Through the Institution's quality assurance system. |

| Basic description | | | |
|---|---|---|---|
| Course title | **Control of Electrical Drives** | | |
| Study programme | **Graduate University Study of Electrical Engineering** | | |
| Course status | compulsory | | |
| Year | **1.** | | |
| ECTS credits and teaching | ECTS student 's workload coefficient | 6 | |
| | Number of hours (L+E+S) | 45+15+0 | |

| 1. **COURSE DESCRIPTION** | | |
|---|---|---|
| *1.1. Course objectives* | | |
| Understanding the requirements of electrical drives. Knowledge of algorithms and methods of controlling electric motor drives. Capability to model, simulate and analyze electric motor drives with different operating mechanisms and different control structures. Introduction to the use of power electronics and microcomputers in regulated electric motor drives. | | |
| *1.2. Course enrolment requirements* | | |
| None. | | |
| *1.3. Expected course learning outcomes* | | |
| Describe mathematical models of drives (drives with DC and AC machines). Make a mathematical and simulation model of the drive and associated control structures. Distinguish control methods for electric motor drives depending on the type of drive and drive requirements. Analyze drive control algorithms. Adjustment of the regulator within the control structures of the regulated electric motor drives. Understand power electronics assemblies used in regulated electric motor drives. Knowing the measurement methods and application of microprocessor control in regulated electric motor drives. Describe modulation methods in a converter circuit. | | |
| *1.4. Course content* | | |
| Introduction in regulated electric motor drives. DC machine control method. Cascade control structures. Converters for DC drives. Technical and symmetrical optimum with application to the adjustment of the controller within the cascade structure. Modulation methods. Scalar model of asynchronous machine and associated control structure. Vector model of an asynchronous machine. Asynchronous machine vector control systems. Space vector modulation. Converters for asynchronous vector control machines. Direct torque control (DTC) method. Measurement methods in electric motor drives. Microprocessor control. Synchronous motor model with permanent magnet and electrical excitation adapted to vector control. Methods of vector control of synchronous machines. Application of cyclo-converters and load-comutated converters in high-power synchronous machines. | | |
| *1.5. Teaching methods* | ☒ lectures<br>☐ seminars and workshops<br>☒ exercises<br>☐ long distance education<br>☐ fieldwork | ☒ individual assignment<br>☐ multimedia and network<br>☒ laboratories<br>☐ mentorship<br>☐ other |
| *1.6. Comments* | | |
| *1.7. Student's obligations* | | |
| Course attendance, activities in class, writing laboratory reports, studying | | |

| *1.8. Evaluation of student's work* | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 2 | Activity/Participation | | Seminar paper | | Experimental work | 1 |
| Written exam | 1.5 | Oral exam | | Essay | | Research | |
| Project | | Sustained knowledge check | 1.5 | Report | | Practice | |
| Portfolio | | | | | | | |

| *1.9. Procedure and examples of learning outcome assessment in class and at the final exam* |
|---|
| Course attendance, activities in class, sustained knowledge checks (tests), written and oral exam |
| *1.10. Assigned reading (at the time of the submission of study programme proposal)* |
| W. Leonhard: Control of Electrical Drives, Springer Verlag, 1996. |
| *1.11. Optional / additional reading (at the time of proposing study programme)* |
| B. K. Bose: Modern Power Electronics and AC Drives, Prentice Hall, 2002.<br>Peter Vas: Vector control of AC machines, Oxford University Press, 1990.<br>B. K. Bose: Power Electronics and Variable Frequencies Drives, John Wiley and Sons, 1996.<br>V. Ambrožič, P. Zajec: Electrical servo drives, Graphis, 2019. (in Croatian) |
| *1.12. Number of assigned reading copies with regard to the number of students currently attending the course* |

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| W. Leonhard: Control of Electrical Drives, Springer Verlag, 1996. | 5 | 60 |
| B. K. Bose: Modern Power Electronics and AC Drives, Prentice Hall, 2002 | 5 | 60 |
| Petar Vas: Vector control of AC machines, Oxford University Press, 1990. | 1 | 60 |
| B. K. Bose: Power Electronics and Variable Frequencies Drives, John Wiley and Sons, 1996. | 0 | 60 |
| V. Ambrožič, P. Zajec: Electrical servo drives, Graphis, 2019. | 2 | 60 |

| *1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences* |
|---|
| Through the Institution's quality assurance systems. |

| Basic description | | |
|---|---|---|
| Course title | **Digital Control Systems** | |
| Study programme | **Graduate University Study of Electrical Engineering** | |
| Course status | optional | |
| Year | **1.** | |
| ECTS credits and teaching | ECTS student 's workload coefficient | 5 |
| | Number of hours (L+E+S) | 30+30+0 |

| 1. **COURSE DESCRIPTION** | | |
|---|---|---|
| *1.1. Course objectives* | | |
| Understanding of discrete control systems. Capability to analyze digital automatic control systems and determine the characteristics of a digital controller. Capability to solve a set problem in order to synthesize a digital control system. Understanding the problems of discrete systems. Capability to describe discrete systems. Capability to model and simulate the behavior of digital control systems in simulation programs. | | |
| *1.2. Course enrolment requirements* | | |
| None. | | |
| *1.3. Expected course learning outcomes* | | |
| Define and distinguish analogue, discrete and digital systems and the basic concepts of such systems. Mathematically describe discreet systems using the Z-transform and transfer functions. Define and analyze precision and stability of discrete systems. Describe and use the root locus method for controler synthesis. Using of computer simulation methods for discrete system analysis and controler parameter identification using the root locus method. Use of analytical and graph-analytical criteria to check the stability of the system. Description and analysis of discrete systems using the state space variables in Z-domain. Define and analyze controllability and observability of discrete systems. Applying computer simulation methods for controler synthesis using feedback state space variables. | | |
| *1.4. Course content* | | |
| Basic terms and definitions, Discrete systems, Mathematical descriptions, Z-transformation and inverse Z-transformation, recursive equations, modified Z-transformation, Transfer function, Stability, Accuracy of digital systems and transient characteristics, Manageability of digital systems, Observability of digital systems Digital controller, Discretization methods, Parameters of digital controller, Digital controller in state space, Procedures for setting parameters of digital controllers, State estimators, Examples of modern digital systems. | | |
| *1.5. Teaching methods* | ☒ lectures<br>☐ seminars and workshops<br>☒ exercises<br>☐ long distance education<br>☐ fieldwork | ☒ individual assignment<br>☐ multimedia and network<br>☐ laboratories<br>☐ mentorship<br>☐ other |
| *1.6. Comments* | | |
| *1.7. Student's obligations* | | |
| Course attendance, activities in class, attending laboratory exercises and writing reports, sustained knowledge checks (two tests and a written test regarding laboratory exercises ), written exam | | |
| *1.8. Evaluation of student's work* | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 2 | Activity/Participation | | Seminar paper | | Experimental work | |
| Written exam | 1 | Oral exam | | Essay | | Research | |
| Project | | Sustained knowledge check | 2 | Report | | Practice | |
| Portfolio | | | | | | | |

*1.9. Procedure and examples of learning outcome assessment in class and at the final exam*

Course attendance, activities in class, attending laboratory exercises and writing reports, sustained knowledge checks (two tests and a written test regarding laboratory exercises ), written exam

*1.10. Assigned reading (at the time of the submission of study programme proposal)*

Matika, D.: Digital control systems, Textbook, TF Rijeka, 2007. (in Croatian)
Vukić, Z. and Kuljača, Lj.: Automatic Control – analysis of linear systems. Zagreb; Kigen, d.o.o., 2004. (in Croatian)
Nise, N.: Control System Engineering. New York; John Wiley and Sons, 2000.

*1.11. Optional / additional reading (at the time of proposing study programme)*

Mitra, S. K: Digital signal processing, A computer – based approach, Second edition, Santa Barbara, University of California, 2000.
Oppenheim, A. V.,Schafer, R. W.: Discrete – time signal processing; Prentice – Hall International, 1989.

*1.12. Number of assigned reading copies with regard to the number of students currently attending the course*

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| Matika, D.: Digital control systems, Textbook, TF Rijeka, 2007. (in Croatian) | 4 | 35 |
| Vukić, Z. and Kuljača, Lj.: Automatic Control – analysis of linear systems. Zagreb; Kigen, d.o.o., 2004. (in Croatian) | 5 | 35 |
| Nise, N.: Control System Engineering. New York; John Wiley and Sons, 2000. | 1 | 35 |
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*1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences*

Through the Institution’s quality assurance systems.

| Basic description | | |
|---|---|---|
| Course title | **Digital Image Processing** | |
| Study programme | **Graduate University Study of Electrical Engineering** | |
| Course status | optional | |
| Year | **2.** | |
| ECTS credits and teaching | ECTS student 's workload coefficient | 6 |
| | Number of hours (L+E+S) | 30+30+0 |

| 1. **COURSE DESCRIPTION** | | |
|---|---|---|
| *1.1. Course objectives* | | |
| Main goal of the course is to gain skills and practical and theoretical knowledge for image processing by using the concept of a digital two-dimensional signal. | | |
| *1.2. Course enrolment requirements* | | |
| None. | | |
| *1.3. Expected course learning outcomes* | | |
| Apply the image analysis and processing methods. Apply basic methods of two-dimensional filtering. Describe image enhancement and restoration methods, image feature extraction, image segmentation and compression. | | |
| *1.4. Course content* | | |
| Sampling, reconstruction and image quantization. Computer- based representation of a digital image. 2-D discrete convolution. 2-D discrete transformations. 2-D filters. Basics of a human visual system. Feature extraction. Image segmentation. Edge detection. Morphological image processing. Application of the wavelet transform in the field of image processing. Image compression. | | |
| *1.5. Teaching methods* | ☒ lectures<br>☐ seminars and workshops<br>☒ exercises<br>☐ long distance education<br>☐ fieldwork | ☒ individual assignment<br>☒ multimedia and network<br>☒ laboratories<br>☐ mentorship<br>☐ other |
| *1.6. Comments* | | |
| *1.7. Student's obligations* | | |
| Class attendance, tests, project work and labs. | | |
| *1.8. Evaluation of student's work* | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 2 | Activity/Participation | 1 | Seminar paper | | Experimental work | |
| Written exam | 1 | Oral exam | | Essay | | Research | |
| Project | 2 | Sustained knowledge check | | Report | | Practice | |
| Portfolio | | | | | | | |

*1.9. Procedure and examples of learning outcome assessment in class and at the final exam*

| |
|---|
| Lectures and labs attendance, project presentation, and final exam. |
| *1.10. Assigned reading (at the time of the submission of study programme proposal)* |
| Gonzalez, R. et al. Digital Image Processing. Prentice Hall, 2007. |
| *1.11. Optional / additional reading (at the time of proposing study programme)* |
| Russ, J. The Image Processing Handbook. CRC Press, 2006. |
| *1.12. Number of assigned reading copies with regard to the number of students currently attending the course* |

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| Gonzalez, R. et al. Digital Image Processing. Prentice Hall, 2007. | | |
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| *1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences* |
| Through the quality assurance system of the Faculty of Engineering. |

| Basic description | | |
|---|---|---|
| Course title | **Digital Signal Processing** | |
| Study programme | **Graduate University Study of Electrical Engineering** | |
| Course status | optional | |
| Year | **1.** | |
| ECTS credits and teaching | ECTS student 's workload coefficient | 6 |
| | Number of hours (L+E+S) | 45+15+0 |

| 1. **COURSE DESCRIPTION** | | |
|---|---|---|
| *1.1. Course objectives* | | |
| Understand both time and frequency analysis and processing methods of discrete-time signals and systems. Understand basic digital filters design methods. Develop problem-solving skills, and analysis and synthesis skills. | | |
| *1.2. Course enrolment requirements* | | |
| None. | | |
| *1.3. Expected course learning outcomes* | | |
| Analyse discrete-time linear time-invariant (LTI) systems in the time domain. Analyse discrete-time LTI systems in the domain of transformation. Explain the process of digital processing of analog signals. Use Discrete Fourier Transform (DFT) in signal spectral analysis and processing. Explain different techniques for designing digital FIR and IIR filters. | | |
| *1.4. Course content* | | |
| Time-domain analysis of discrete-time LTI systems (convolution, difference equations). Analysis of discrete-time LTI systems in the domain of transformation (Discrete-Time Fourier Transform and Z transform). Digital processing of analog signals. Discrete Fourier Transform (properties and applications in signal spectral analysis). Basic techniques of FIR and IIR digital filters design (time-windows, bilinear transformation). | | |
| *1.5. Teaching methods* | ☒ lectures<br>☐ seminars and workshops<br>☒ exercises<br>☐ long distance education<br>☐ fieldwork | ☒ individual assignment<br>☐ multimedia and network<br>☐ laboratories<br>☐ mentorship<br>☐ other |
| *1.6. Comments* | - | |
| *1.7. Student's obligations* | | |
| Course attendance, project work, individual studying. | | |
| *1.8. Evaluation of student's work* | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 2 | Activity/Participation | | Seminar paper | | Experimental work | |
| Written exam | 1 | Oral exam | | Essay | | Research | |
| Project | 1 | Sustained knowledge check | 2 | Report | | Practice | |
| Portfolio | | | | | | | |

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| *1.9. Assessment and evaluation of student's work during classes and on final exam* |
| Written tests, project report, written exam. |
| *1.10. Assigned reading (at the time of the submission of study programme proposal)* |
| B. P. Lathi and R. A. Green: Essentials of Digital Signal Processing, Cambridge University Press, 2014. |
| *1.11. Optional / additional reading (at the time of proposing study programme)* |
| M. H. Hayes: Digital Signal Processing, 2/E, McGraw-Hill, 2012.<br><br>R. J. Schilling and S. L. Harris: Fundamentals of Digital Signal Processing Using MATLAB, Thomson, 2005. |
| *1.12. Number of assigned reading copies with regard to the number of students currently attending the course* |

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| B. P. Lathi and R. A. Green: Essentials of Digital Signal Processing, Cambridge University Press, 2014. | 2 | 40 |

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|---|
| *1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences* |
| Through the Institution's quality assurance system. |

| Basic description | | |
|---|---|---|
| Course title | **Driving and Operating Engines** | |
| Study programme | **Graduate University Study of Electrical Engineering** | |
| Course status | optional | |
| Year | **1.** | |
| ECTS credits and teaching | ECTS student 's workload coefficient | 6 |
| | Number of hours (L+E+S) | 45+15+0 |

| 1. **COURSE DESCRIPTION** | | |
|---|---|---|
| *1.1. Course objectives* | | |
| Adoption of basic knowledge and skills to identify and solve practical problems in the field of driving and operating machines in the conversion of energy, as a basis for understanding the machines that drive generators or are driven by electric motors. This knowledge helps in understanding mutual connections between electrical and mechanical engineering. | | |
| *1.2. Course enrolment requirements* | | |
| None. | | |
| *1.3. Expected course learning outcomes* | | |
| Application of the laws of thermodynamics and fluid mechanics in the processes of energy conversion in driving and operating machinery. Analysis of the theoretical energy conversion processes in driving and operating machinery. Application of the laws of fluid mechanics to conversions of energy in hydraulic driving and operating machines. Analysis of the processes of energy conversion processes in hydraulic driving and operating machinery. Energy states in the pipelines. Application of the laws of thermodynamics and fluid mechanics to working processes in heat engines. Analysis of the operating processes in driving heat engines and the effect of parameters on their characteristics. Application of the laws of thermodynamics and fluid mechanics to processes in operating heat engines. Analysis of the processes in driving heat engines and the effect of parameters on their characteristics. Analysis of machines for converting energy from renewable sources. | | |
| *1.4. Course content* | | |
| Introduction to driving and working machines. The properties of fluids. Fundamentals of energy conversion in the machines. Losses in energy conversion processes. Rational use of energy. Hydraulic turbines. Hydroelectric power plants. Rotodynamic pumps. Reciprocating pumps. Application of pumps. Hydraulic transmissions. Steam generators. Steam turbines. Steam turbine power plants. Nuclear power. Condensers. Turbocompressors. Reciprocating compressors. Cooling devices. Gas turbines. Gas-turbine power plants. Combined gas and steam turbines plant. The jet and rocket engines. Internal combustion engines. Emissions and environmental protection. | | |
| *1.5. Teaching methods* | ☒ lectures<br>☐ seminars and workshops<br>☒ exercises<br>☐ long distance education<br>☒ fieldwork | ☒ individual assignment<br>☐ multimedia and network<br>☐ laboratories<br>☐ mentorship<br>☐ other |
| *1.6. Comments* | None | |
| *1.7. Student's obligations* | | |

Course attendance, activity, homework, studying.

*1.8. Evaluation of student's work*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 2 | Activity/Participation | | Seminar paper | | Experimental work | |
| Written exam | 1 | Oral exam | 1 | Essay | | Research | |
| Project | 1 | Sustained knowledge check | 1 | Report | | Practice | |
| Portfolio | | Homework | | | | | |

*1.9. Procedure and examples of learning outcome assessment in class and at the final exam*

Course attendance, activity, homework, continuous knowledge testing (two mid-term exams), written and oral exam.

*1.10. Assigned reading (at the time of the submission of study programme proposal)*

Prelec, Z.: Energy Engineering in Process Industry, Školska knjiga Zagreb, 1984. (in Croatian)
Govinda Rao, N.S.: Fluid Flow Machines, TATA McGrow Hill Publishing Co., 1986.
Kharchenko, N.V.: Advanced Energy Systems, Taylor & Francis Group, 1997.

*1.11. Optional / additional reading (at the time of proposing study programme)*

Decher, R.: Energy Conversion: Systems, Flow Physics and Engineering, Oxford University Press, 1994.

*1.12. Number of assigned reading copies with regard to the number of students currently attending the course*

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| Prelec, Z.: Energy Engineering in Process Industry, Školska knjiga Zagreb, 1984. (in Croatian) | 5 | 40 |
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*1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences*

Through the Institution's quality assurance system.

| Basic description | | |
|---|---|---|
| Course title | **Electric Power Plants** | |
| Study programme | **Graduate University Study of Electrical Engineering** | |
| Course status | optional | |
| Year | **1.** | |
| ECTS credits and teaching | ECTS student 's workload coefficient | 5 |
| | Number of hours (L+E+S) | 45+15+0 |

## 1. COURSE DESCRIPTION

### *1.1. Course objectives*

Understanding functioning specifics of the primary equipment and components of hydropower plants, thermal power plants, nuclear power plants and alternative power plants. Ability to determine the most important technical and economic characteristics of power plants. Understanding interactions among power plants and the power system.

### *1.2. Course enrolment requirements*

None.

### *1.3. Expected course learning outcomes*

Distinguish different types of power plants. Define basic parts of power plants. Describe turbine and generator types. Analyze energy performance of power plants. Calculate power plant's production estimate. Compare production costs among different types of power plants. Describe power plant control actions (active and reactive power), frequency and voltage control. Describe and compare power plants' environmental impact. Analyze measures to reduce environmental impact of different types of power plants. Define site selection criteria for the construction of power plants. Argue the need for stronger implementation of renewable energy sources.

### *1.4. Course content*

Energy and energy conversion fundamentals. Power plant types and classification. Available power and possible energy production. Power plants (hydro, thermal, nuclear). Exploitation characteristics. Power plant's main parts and systems. Turbine types. Nuclear power plants – reactor types. Thermodynamic cycle diagrams and thermal schemes. Wind power, solar power, biogas and geothermal power plants. Power plant's main equipment characteristics. Startup, shutdown and power change capabilities of power plants. Power plant's one-line connection diagrams. Synchronous generator parameters and capability curves. Generator synchronization. General and self-consumption of power plants. Emergency and back-up power sources.

| | | |
|---|---|---|
| *1.5. Teaching methods* | ☒ lectures<br>☒ seminars and workshops<br>☒ exercises<br>☐ long distance education<br>☒ fieldwork | ☐ individual assignment<br>☐ multimedia and network<br>☒ laboratories<br>☐ mentorship<br>☐ other |
| *1.6. Comments* | | |

### *1.7. Student's obligations*

| |
|---|
| Course attendance, seminars, studying. |
| *1.8. Evaluation of student's work* |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 2 | Activity/Participation | | Seminar paper | 0.5 | Experimental work | |
| Written exam | 0.5 | Oral exam | 0.5 | Essay | | Research | |
| Project | | Sustained knowledge check | 1.5 | Report | | Practice | |
| Portfolio | | | | | | | |

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|---|
| *1.9. Procedure and examples of learning outcome assessment in class and at the final exam* |
| Course attendance, seminar, continuous knowledge testing (two mid-term exams), written and oral exam. |
| *1.10. Assigned reading (at the time of the submission of study programme proposal)* |
| Ujević, L., Buntić, Z.: Power plants, Školska knjiga, Zagreb, 1993. (in Croatian)<br>Požar, H.: Basics of power engineering 1, Školska knjiga, Zagreb, 1992. (in Croatian)<br>Požar, H.: Basics of power engineering 2, Školska knjiga, Zagreb, 1992. (in Croatian)<br>Kalea, M.: Renewable energy sources – energy perspective, Kiklos krug knjige, Zagreb, 2014. (in Croatian) |
| *1.11. Optional / additional reading (at the time of proposing study programme)* |
| Požar, H.: Production of electrical energy, Sveučilište u Zagrebu, Zagreb, 1962. (in Croatian) |
| *1.12. Number of assigned reading copies with regard to the number of students currently attending the course* |

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| Ujević, L., Buntić, Z.: Power plants, Školska knjiga, Zagreb, 1993. (in Croatian) | 7 | 21 |
| Požar, H.: Basics of power engineering 1, Školska knjiga, Zagreb, 1992. (in Croatian) | 3 | 21 |
| Požar, H.: Basics of power engineering 2, Školska knjiga, Zagreb, 1992. (in Croatian) | 5 | 21 |
| Kalea, M.: Renewable energy sources – energy perspective, Kiklos krug knjige, Zagreb, 2014. (in Croatian) | 4 | 21 |

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|---|
| *1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences* |
| Through the Institution's quality assurance system. |

| Basic description | | |
|---|---|---|
| Course title | **Electric Power Substation Design** | |
| Study programme | **Graduate University Study of Electrical Engineering** | |
| Course status | optional | |
| Year | **1.** | |
| ECTS credits and teaching | ECTS student 's workload coefficient | 5 |
| | Number of hours (L+E+S) | 45+30+0 |

| 1. **COURSE DESCRIPTION** | | |
|---|---|---|
| *1.1. Course objectives* | | |
| Introduction to activities during all phases of an electric power substation design. Substation's electric parameter calculation and selection of primary and secondary equipment. Ability to establish substation's essential technical requirements, and define typical configurations and solutions. | | |
| *1.2. Course enrolment requirements* | | |
| None. | | |
| *1.3. Expected course learning outcomes* | | |
| Describe the designing process of electric power substations. Distinguish different types of projects and permits for substation construction. Apply simplified methods for calculating short-circuit currents. Compare short-circuit currents by different voltage levels. Calculation of short-circuit currents in DC circuits. Analyze typical circuit diagrams of electrical installations. Describe typical high and medium voltage substation bay designs. Describe protection principles against lightning overvoltages. Describe the characteristics of the surge arresters. Classify low voltage utility/consumer interfaces. Define a methodological approach to electromagnetic compatibility. Apply ePLAN computer package for electrical power substation design. | | |
| *1.4. Course content* | | |
| Introduction to electric power substation design. Fundamentals of engineering. Standards. IEC standards. Relevant legislation. Tests, attests. The structure of the power system. Distribution system. Design chronology and substation construction. Terms of reference. Electric power substation designing phases. Site selection and data collection. Designing, drawings and documentation. (CAD). Electric permit, location permit, construction and other permits. Inspection and supervision of construction works and equipment production. Construction, testing and commissioning. Security. Environmental impact. Electromagnetic influence. Short circuit calculation methods. Typical bus configurations. Insulation and insulation protection. Transformers. Circuit breakers and disconnectors. Overvoltage protection. Secondary equipment. Instrument transformers. Substation auxiliary systems. Grounding. Grounding design considerations. Harmonics. | | |
| *1.5. Teaching methods* | ☒ lectures<br>☐ seminars and workshops<br>☒ exercises<br>☐ long distance education<br>☐ fieldwork | ☒ individual assignment<br>☐ multimedia and network<br>☒ laboratories<br>☐ mentorship<br>☐ other |
| *1.6. Comments* | | |
| *1.7. Student's obligations* | | |
| Course attendance, project, studying. | | |
| *1.8. Evaluation of student's work* | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 2.5 | Activity/Participation | | Seminar paper | | Experimental work | |
| Written exam | 0.5 | Oral exam | 0.5 | Essay | | Research | |
| Project | 0.5 | Sustained knowledge check | 1 | Report | | Practice | |
| Portfolio | | | | | | | |

*1.9. Procedure and examples of learning outcome assessment in class and at the final exam*

Course attendance, project, continuous knowledge testing (two mid-term exams), written and oral exam.

*1.10. Assigned reading (at the time of the submission of study programme proposal)*

Badanjak, S.: Fundamentals of Engineering in construction, Energetika marketing, Zagreb, 1996. (in Croatian)

*1.11. Optional / additional reading (at the time of proposing study programme)*

D. McDonald, J.D.: Electric Power Substations Engineering, CRC Press, 2001.

*1.12. Number of assigned reading copies with regard to the number of students currently attending the course*

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| Badanjak, S.: Fundamentals of Engineering in construction, Energetika marketing, Zagreb, 1996. (in Croatian) | 1 | 21 |

*1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences*

Through the Institution's quality assurance system.

| Basic description | | |
|---|---|---|
| Course title | **Electric Power System Management** | |
| Study programme | **Graduate University Study of Electrical Engineering** | |
| Course status | optional | |
| Year | **2.** | |
| ECTS credits and teaching | ECTS student 's workload coefficient | 5 |
| | Number of hours (L+E+S) | 30+30+0 |

| 1. **COURSE DESCRIPTION** | | |
|---|---|---|
| *1.1. Course objectives* | | |
| The course is a professional discipline for all the students of the electric power system studies. The goal is to introduce the students to power system control, with focus on regulation, monitoring and management. | | |
| *1.2. Course enrolment requirements* | | |
| None. | | |
| *1.3. Expected course learning outcomes* | | |
| Define and describe functions of electric power system control in real and expanded real time. Analyse electric power system regulations, with the focus on primary, secondary and tertiary regulation of frequency. Define and distinguish the regulation of frequency and active power in comparison with the regulation of voltage and reactive power. Describe human-machine interface and visualization of the power system control on plant level and on system level (SCADA). Define and describe the Wide Area Monitoring system (WAM) based on synchronized phasor measurements, in function of electric power system control. | | |
| *1.4. Course content* | | |
| The definition of electric power system control and description of electric power system regulation, with the overview of basic characteristics of primary, secondary and tertiary regulation of frequency. The regulation of frequency and active power, the regulation of voltage and reactive power, frequency collapse, under-frequency shedding. The overview of devices for voltage and reactive power regulation.<br>The overview of automated and computer supported control of electrical power plants on device level, field level and plant level. The description of the classical centralized structure of remote units and the new distributed concept of microprocessor remote units with a central unit in the plant. Human machine interfaces and visualization of electric power system control process. The technological description of structure of sources and the overview of communication of process information in plants and between plants and control centres. The description of structure of user design of process information in electric power system control centres. Advanced technologies for power system operation, protection and control – smart grids. | | |
| *1.5. Teaching methods* | ☒ lectures<br>☒ seminars and workshops<br>☒ exercises<br>☐ long distance education<br>☒ fieldwork | ☐ individual assignment<br>☐ multimedia and network<br>☒ laboratories<br>☐ mentorship<br>☐ other |
| *1.6. Comments* | | |
| *1.7. Student's obligations* | | |
| Course attendance, activity, seminar paper, studying. | | |

*1.8. Evaluation of student's work*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 2 | Activity/Participation | | Seminar paper | 0.5 | Experimental work | |
| Written exam | 1 | Oral exam | | Essay | | Research | |
| Project | | Sustained knowledge check | 1.5 | Report | | Practice | |
| Portfolio | | | | | | | |

*1.9. Procedure and examples of learning outcome assessment in class and at the final exam*

Course attendance, activity, seminar paper, continuous knowledge testing (two mid-term exams), written exam.

*1.10. Assigned reading (at the time of the submission of study programme proposal)*

P. Kundur: Power System Stability and Control, McGraw-Hill, USA, 1994
P. M. Anderson, A. A. Fouad: Power System Control and Stability, Wiley, 2002

*1.11. Optional / additional reading (at the time of proposing study programme)*

S. Tešnjak: (f-P) and (U-Q) regulations in electric power system, Department script, Faculty of electrical engineering and computing, University of Zagreb, Zagreb, 1991
J. Machowski, J.W. Bialek, J.R. Bumby: Power System Dynamics and Stability, Wiley, UK, 1997
E. Mariani, S.S. Murthy: Control of Modern Integrated Power Systems, Springer-Verlag, UK, 1997

*1.12. Number of assigned reading copies with regard to the number of students currently attending the course*

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| P. Kundur: Power System Stability and Control, McGraw-Hill, USA, 1994 | 1 | 35 |
| P. M. Anderson, A. A. Fouad: Power System Control and Stability, Wiley, 2002 | 1 | 35 |

*1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences*

Through the Institution's quality assurance system.

| Basic description | | |
|---|---|---|
| Course title | **Electric Power Systems** | |
| Study programme | **Graduate University Study of Electrical Engineering** | |
| Course status | optional | |
| Year | **2.** | |
| ECTS credits and teaching | ECTS student 's workload coefficient | 6 |
| | Number of hours (L+E+S) | 30+30+0 |

| 1. **COURSE DESCRIPTION** | | |
|---|---|---|
| *1.1. Course objectives* | | |
| Understanding the need to maintain balance between electric energy production and demand. Understanding the interrelationship among demand prediction and production schedules, based on technical and economic requirements. Ability to determine dynamic parameters of the power system. Understanding the scope of transmission functions within the power system. | | |
| *1.2. Course enrolment requirements* | | |
| None. | | |
| *1.3. Expected course learning outcomes* | | |
| Analysis of the power system. Power system daily load profiles analysis. Forecasting electric demand. Describe methods to maintain balance between electric power production and demand. Electricity production analysis. Define electric energy transmission and distribution. Define process control characteristics of systems for production and transmission of electrical energy. Define power system frequency stability. Define power system voltage stability. Describe underfrequency and undervoltage load shedding principles. Define static and dynamic stability of the power system. Understanding the interaction between theory and empirical observation. Planning of power systems and their functioning. | | |
| *1.4. Course content* | | |
| Daily load profiles. Power plants day-ahead production plans. Economic operation of the power system. Process control characteristics of systems for production and transmission of electrical energy. Maintaining stability of frequency and voltage in power systems. Automatic frequency and voltage control sensitivity analysis of power systems. Primary and secondary regulation systems for frequency and voltage control in electric power systems. Power system underfrequency and undervoltage load shedding. Demand forecasting. Conceptual problems in determining the transfer functions of the power system. System operator functions directed to coordination and centralization. The course of function changes in the electric power system in which decentralized participation in making decisions is implemented. Resulting extent of transmission functions within the power system. Understanding the interaction between theory and empirical observation. Planning of power systems and their functioning. | | |
| *1.5. Teaching methods* | ☒ lectures<br>☐ seminars and workshops<br>☒ exercises<br>☐ long distance education<br>☐ fieldwork | ☒ individual assignment<br>☐ multimedia and network<br>☒ laboratories<br>☐ mentorship<br>☐ other |
| *1.6. Comments* | | |
| *1.7. Student's obligations* | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance, project, studying. | | | | | | | |
| *1.8. Evaluation of student's work* | | | | | | | |
| Course attendance | 2 | Activity/Participation | | Seminar paper | 0.5 | Experimental work | |
| Written exam | 1.5 | Oral exam | 0.5 | Essay | | Research | |
| Project | | Sustained knowledge check | 1.5 | Report | | Practice | |
| Portfolio | | | | | | | |
| *1.9. Procedure and examples of learning outcome assessment in class and at the final exam* | | | | | | | |
| Course attendance, project, continuous knowledge testing (two mid-term exams), written and oral exam. | | | | | | | |
| *1.10. Assigned reading (at the time of the submission of study programme proposal)* | | | | | | | |
| Udovičić, B.: Electric power system, Kigen, Zagreb, 2005. (in Croatian) | | | | | | | |
| *1.11. Optional / additional reading (at the time of proposing study programme)* | | | | | | | |
| Višković, A. and group of authors: Power engineering in the EU countries in the nineties, Kigen,Zagreb, 2005. (in Croatian)<br>Chao, H.-P., Huntington, H.G.: Designing competitive electricity markets, Kluweer Academic Publisher, SF, 2001.<br>Kundur, D.P.: Power System Stability and Control, McGraw-Hill, Inc., New York, USA, 1994.<br>Anderson, P.M., Fouad, A.A.: Power System Control and Stability (Revised printing), IEEE Press, New York, 1994.<br>Taylor. C.W.: Power System Voltage Stability, McGraw Hill, Inc., New York, 1994. | | | | | | | |
| *1.12. Number of assigned reading copies with regard to the number of students currently attending the course* | | | | | | | |

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| Udovičić, B.: Electric power system, Kigen, Zagreb, 2005. (in Croatian) | 3 | 32 |

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| *1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences* |
| Through the Institution's quality assurance system. |

| Basic description | | |
|---|---|---|
| Course title | **Electricity Market** | |
| Study programme | **Graduate University Study of Electrical Engineering** | |
| Course status | optional | |
| Year | **2.** | |
| ECTS credits and teaching | ECTS student 's workload coefficient | 5 |
| | Number of hours (L+E+S) | 30+30+0 |

| 1. **COURSE DESCRIPTION** | | | | | | | |
|---|---|---|---|---|---|---|---|
| *1.1. Course objectives* | | | | | | | |
| Understanding the liberalisation process of the power system, functioning of electricity markets with regard to electricity market design and regulatory framework. | | | | | | | |
| *1.2. Course enrolment requirements* | | | | | | | |
| Attended course Electric Power Plants. | | | | | | | |
| *1.3. Expected course learning outcomes* | | | | | | | |
| Describe the liberalisation of the electric power system. Define the electricity market. Analyze the various structures and organizations of the market. Describe the basics of an auction mechanism. Define marginal costs. Define bilateral agreements. Distinguish types of independent system operators. Evaluate the impact of the power system on the market. Analyze mandatory and commercial services. Define the congestion in the transmission of electricity as a result of market transactions. Understand the liberalisation process and the development of energy markets as well as the theory of market design. | | | | | | | |
| *1.4. Course content* | | | | | | | |
| The restructuring of the electricity sector. The electricity market and system services. Different structure and organization of the market. Basics of an auction mechanism. Marginal costs. Opportunity costs. Bilateral agreements. Market power. Definitions and types of independent system operators (minimalist and maximalist model). The impact of power sector's service on the market, i.e. the price of electricity. The problems of determining the ways of measuring and billing with regard to new conditions. Mandatory and commercial services. Congestion in the transmission of electricity as a result of market transactions. The question of market design; industry structure, power exchange, market design, market models. "European" mode, hybrid model. | | | | | | | |
| *1.5. Teaching methods* | ☒ lectures<br>☐ seminars and workshops<br>☒ exercises<br>☐ long distance education<br>☐ fieldwork | | | ☒ individual assignment<br>☐ multimedia and network<br>☐ laboratories<br>☐ mentorship<br>☐ other | | | |
| *1.6. Comments* | | | | | | | |
| *1.7. Student's obligations* | | | | | | | |
| Course attendance, project, studying. | | | | | | | |
| *1.8. Evaluation of student's work* | | | | | | | |
| Course attendance | 2 | Activity/Participation | 0.5 | Seminar paper | 0.5 | Experimental work | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Written exam | 0.5 | Oral exam | 0.5 | Essay | | Research | |
| Project | | Sustained knowledge check | 1 | Report | | Practice | |
| Portfolio | | | | | | | |

*1.9. Procedure and examples of learning outcome assessment in class and at the final exam*

Course attendance, project, continuous knowledge testing (two mid-term exams), written and oral exam.

*1.10. Assigned reading (at the time of the submission of study programme proposal)*

Boisseleau, F.: The role of power exchanges: For the creation of a single European electricity market: market design and market regulation., Lambert Academic Publishing, 2012
Višković, A.: Economy and the policy of eletric energy production, Kigen, Zagreb, 2007 (in Croatian)
Tešnjak, S., Kuzle, I., Braovac, E.: Electricity market, Graphis, Zagreb, 2004 (in Croatian)

*1.11. Optional / additional reading (at the time of proposing study programme)*

Piani, G., Višković, A., Saftić, B.: Kyoto protocol. The realization and future development, legislation, strategies, technologies, GRAPHIS, Zagreb, 2011 (in Croatian)
Glachant, J-M., Leveque, F.: Electricity Reform in Europe, Towards a Single Energy Market, Edward Elgar, UK, 2009
Višković, A. and a group of authors: Power engineering in the EU countries in the nineties, Kigen,Zagreb, 2005 (in Croatian)

*1.12. Number of assigned reading copies with regard to the number of students currently attending the course*

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| Boisseleau, F.: The role of power exchanges: For the creation of a single European electricity market: market design and market regulation, Lambert Academic Publishing, 2012. | 0 | 40 |
| Višković, A.: Economy and the policy of eletric energy production, Kigen, Zagreb, 2007. | 0 | 40 |
| Tešnjak, S., Kuzle, I., Banovac, E.: Electricity market, Graphis, Zagreb, 2004. | 0 | 40 |

*1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences*

Through the Institution’s quality assurance system.

| Basic description | | | |
|---|---|---|---|
| Course title | **Electromagnetics** | | |
| Study programme | **Graduate University Study of Electrical Engineering** | | |
| Course status | optional | | |
| Year | **1.** | | |
| ECTS credits and teaching | ECTS student 's workload coefficient | 6 | |
| | Number of hours (L+E+S) | 45+30+0 | |

| 1. **COURSE DESCRIPTION** | | |
|---|---|---|
| *1.1. Course objectives* | | |
| Understanding the basic concept of electromagnetism with examples from power systems. The emphasis is on static and low frequency fields. Understanding the basic numerical techniques in solving electric and magnetic fields. Training for field calculations using modern CAD tools. | | |
| *1.2. Course enrolment requirements* | | |
| None. | | |
| *1.3. Expected course learning outcomes* | | |
| Explain the concept of electromagnetic theory. Apply vector analysis in the context of electromagnetic fields. Describe properties of static and time-dependent fields. Explain the physical meaning of Maxwell's equations. Describe the underlying mathematical principles of electromagnetism. Describe the electrical and magnetic properties of a material. Assess the role of electromagnetism in computer engineering. Identify the different equations describing electromagnetic processes. Derive the equations describing electromagnetic phenomena. Formulate the basic laws of electromagnetism. Analyze simple electromagnetic system. Apply electromagnetic theory in simple practical situations. Explain the meaning and consequences of quantum field theory. Interpret solutions. Apply modeling and simulation techniques related to low-frequency electromagnetic fields. Explain the basics of finite-difference method and finite element method. Explain the advantages and limitations of different methods. Explain the component of CAD systems in electromagnetism. Apply FEM programs. Apply CAD programs to create a virtual prototype of electromagnetic devices. | | |
| *1.4. Course content* | | |
| Vector analysis. Coulomb's law and electric field strength. Gauss' law and divergence. Energy and potential. Conductors, insulators and capacity. Poisson's and Laplace equation. The static magnetic field, magnetic forces, materials and inductance. The time variable magnetic field and Maxwell's equations. Potentials and potential equations. Numerical methods the implementation of the electric and magnetic fields calculations. Modeling and simulation of electromagnetic devices with finite element method. | | |
| *1.5. Teaching methods* | ☒ lectures<br>☐ seminars and workshops<br>☒ exercises<br>☐ long distance education<br>☐ fieldwork | ☐ individual assignment<br>☐ multimedia and network<br>☒ laboratories<br>☐ mentorship<br>☐ other |
| *1.6. Comments* | | |
| *1.7. Student's obligations* | | |
| Lectures, activity, activity in laboratory, studying. | | |

| *1.8. Evaluation of student's work* | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 2.5 | Activity/Participation | | Seminar paper | | Experimental work | |
| Written exam | 1 | Oral exam | 0.5 | Essay | | Research | |
| Project | | Continuous knowledge testing | 2 | Report | | Practice | |
| Portfolio | | | | | | | |

*1.9. Procedure and examples of learning outcome assessment in class and at the final exam*

Course attendance, laboratory, continuous knowledge testing, written and oral exam.

*1.10. Assigned reading (at the time of the submission of study programme proposal)*

Z. Haznadar, Ž. Štih: Elektromagnetism I, II, Školska knjiga, Zagreb, 1997

*1.11. Optional / additional reading (at the time of proposing study programme)*

W. H. Hayt, J. A. Buck: Engineering Electromagnetics, McGRAW-HILL, 2001.
J. D. Kraus, D.A.Fleish: Electromagnetics with application, McGraw-Hill International Editions, 1999
J. P. Bastos, N. Sadowski: Electromagnetic Modeling by Finite Element Methods. Marcel Dekker, Inc, NY,2003

*1.12. Number of assigned reading copies with regard to the number of students currently attending the course*

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| Z. Haznadar, Ž. Štih: Elektromagnetism I, II, Školska knjiga, Zagreb, 1997 (in Croatian) | 1 | 54 |

*1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences*

Through the Institution's quality assurance system.

| Basic description | | |
|---|---|---|
| Course title | **Evolutionary Robotics** | |
| Study programme | **Graduate University Study of Electrical Engineering** | |
| Course status | optional | |
| Year | **2.** | |
| ECTS credits and teaching | ECTS student 's workload coefficient | 5 |
| | Number of hours (L+E+S) | 30+30+0 |

## 1. COURSE DESCRIPTION

*1.1. Course objectives*

This course provides theoretical knowledge in this field, along with the study of specific algorithms for multiple robot control and embedded systems. Programming assignments and exams are basic methods of assessment, programming in robotic simulation environment

*1.2. Course enrolment requirements*

None.

*1.3. Expected course learning outcomes*

Define and describe distributive intelligence in the context of distributivity. Define tasks and describe and compare the cooperative robotics and embedded systems. Describe and analyze the performance of robotic architecture and selection activities, cooperative localization, mapping and exploration, cooperative object transportation, coordination of robotic motion, Reconfigurable robotics and group learning. Describe and analyze algorithms and software that enables group distribution of intelligent mobile robots and embedded systems for the purpose of achieving the global goal. Describe and analyze the performance of a hierarchical robot control. Apply meta-heuristic algorithms in trajectory planning of mobile and industrial robots. Describe and analyze the performance management of the robot based on behavior. Describe the sensors and perception, navigation and path planning. Describe the basic characteristics and analyze localization in robotics, and learning from mistakes. Apply the knowledge on selective models in robotics, with an emphasis on mobile robots and cooperative purchase behavior.

*1.4. Course content*

This course explores the topic distribution Intelligence locally or distributivity context, collective and cooperative robotics and embedded systems. The focus will be on major research themes: more robotic architecture and selection activities, cooperative localization, mapping and exploration, cooperative object transportation, more robotic motion coordination, Reconfigurable robotics and group learning. The emphasis in all these issues is to develop algorithms and software that will enable the group distribution of intelligent mobile robots and embedded systems for the purpose of achieving the global goal in a real environment using only the distribution, local information. The main topics that will be discussed: a hierarchical robot control, robot control based on behavior, sensors and perception, navigation and path planning, localization, learning from mistakes, multiple robotic systems, and a meta-heuristic approach to mobile trajectory planning and industrial robots.

| | | |
|---|---|---|
| *1.5. Teaching methods* | ☒ lectures<br>☐ seminars and workshops<br>☒ exercises<br>☐ long distance education<br>☐ fieldwork | ☒ individual assignment<br>☐ multimedia and network<br>☒ laboratories<br>☐ mentorship<br>☐ other |
| *1.6. Comments* | | |

*1.7. Student's obligations*

Attendance, activities in the classroom, homework and self-study.

*1.8. Evaluation of student's work*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 2 | Activity/Participation | 0.5 | Seminar paper | 0.5 | Experimental work | |
| Written exam | 0.5 | Oral exam | 0.5 | Essay | | Research | |
| Project | | Sustained knowledge check | 0.5 | Report | | Practice | 0.5 |
| Portfolio | | Homework | | | | | |

*1.9. Procedure and examples of learning outcome assessment in class and at the final exam*

Attendance, activities in the classroom, homework, two control written exam and final oral and written exam.

*1.10. Assigned reading (at the time of the submission of study programme proposal)*

The Horizons of Evolutionary Robotics (Intelligent Robotics and Autonomous Agents series), 2014.
Siegwart R., Nourbakhsh I. R., Scaramuzza D., Introduction to Autonomous Mobile Robots (Intelligent Robotics and Autonomous Agents series), 2011.
Robin R. Murphy, An Introduction to AI Robotics (Intelligent Robotics and Autonomous Agents) , 2006.
Holland, J.M., Designing Autonomous Mobile Robots, 2003

*1.11. Optional / additional reading (at the time of proposing study programme)*

Enaction, Embodiment, Evolutionary Robotics: Simulation Models for a Post-Cognitivist Science of Mind (Atlantis Thinking Machines), 2010.
Nolfi, S., Floreano, D., Evolutionary Robotics : The Biology, Intelligence, and Technology of Self Organizing Machines, 2004.
Bramer, M., Devedzic, I, Artificial Intelligence application and Innovations, 2004.
Borenstein, J., Everett, H.R., and Feng, L., Where am I?: Sensors and Methods for Mobile Robot Positioning, 1996
Murphy, Robin R. Introduction to AI robotics. MIT press, 2019.
Grupen, R. The Developmental Organization of Robot Behavior, MIT Press, 2021.
Thrun, Sebastian, Wolfram Burgard, and Dieter Fox. Probalistic robotics. Kybernetes 2006.
Hamann, Heiko. Swarm Robotics: A Formal Approach, Springer, 2018

*1.12. Number of assigned reading copies with regard to the number of students currently attending the course*

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| Robin R. Murphy, An Introduction to AI Robotics (Intelligent Robotics and Autonomous Agents), 2000. | 1 | |
| Siegwart R., Nourbakhsh I. R., Scaramuzza D., Introduction to Autonomous Mobile Robots (Intelligent Robotics and Autonomous Agents series), 2011. | 1 | |
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*1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences*

Through a structured quality assurance system of the Faculty.

| Basic description | | | |
|---|---|---|---|
| Course title | **Fundamentals of Robotics** | | |
| Study programme | **Graduate University Study of Electrical Engineering** | | |
| Course status | optional | | |
| Year | **1.** | | |
| ECTS credits and teaching | ECTS student 's workload coefficient | 6 | |
| | Number of hours (L+E+S) | 45+15+0 | |

| 1. COURSE DESCRIPTION | | |
|---|---|---|
| *1.1. Course objectives* | | |
| This course provides knowledge of industrial robots and skills in modeling the kinematics and dynamics of robots, planning and execution of planned trajectories and application of various methods of robot control. Training students for independent simulations in the ABB Robot Studio software package, and numerical simulations using the Python programming language. Developing the ability to work independently and work in small groups (team work) and display the results achieved. | | |
| *1.2. Course enrolment requirements* | | |
| None. | | |
| *1.3. Expected course learning outcomes* | | |
| Describe robot types and their characteristics. Describe forms and characteristics of robot elements. Define position and orientation of rigid body. Define Denavit-Hartenberg algorithm. Apply kinematics and inverse kinematics. Apply Lagrange-Euler and Newton-Euler robot dynamics modelling methods. Describe trajectory planning for point to point and continuous path movements. Analyse robot trajectory interpolation methods. Analyse different robot servo system control algorithms. | | |
| *1.4. Course content* | | |
| Robot types and their characteristics. Forms and characteristics of robot elements. Position and orientation of rigid body. Denavit-Hartenberg algorithm. Kinematics and inverse kinematics. Modelling of robot dynamics. Lagrange-Euler and Newton-Euler robot dynamics methods. Trajectory planning for point to point and continuous path movements. Robot trajectory interpolation methods. Different algorithms for control of robot joint servo systems coordinates (position, speed, torque and force). | | |
| *1.5. Teaching methods* | ☒ lectures<br>☐ seminars and workshops<br>☒ exercises<br>☐ long distance education<br>☐ fieldwork | ☒ individual assignment<br>☐ multimedia and network<br>☒ laboratories<br>☐ mentorship<br>☐ other |
| *1.6. Comments* | | |
| *1.7. Student's obligations* | | |
| Course attendance, activity, simulation exercises, studying. | | |
| *1.8. Evaluation of student's work* | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 2 | Activity/Participation | | Seminar paper | | Experimental work | |
| Written exam | 1 | Oral exam | | Essay | | Research | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Project | | Sustained knowledge check | 1.5 | Report | | Practice | |
| Portfolio | | Simulation exercises | 1.5 | | | | |

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| *1.9. Procedure and examples of learning outcome assessment in class and at the final exam* |
| Oral explanation of simulation exercises or project task, continuous knowledge test (two control tasks), written final exam. |
| *1.10. Assigned reading (at the time of the submission of study programme proposal)* |
| B. Siciliano, K. Oussama: Springer handbook of robotics. Springer, 2016. |
| *1.11. Optional / additional reading (at the time of proposing study programme)* |
| L. W. Tsai: Robot analysis: the mechanics of serial and parallel manipulators. John Wiley & Sons, 1999.<br>L. T. Ross, S. W. Fardo, M. F. Walach: Industrial Robotics, The Goodheart-Willcox Company, 2008.<br>Z. Kovačić, S. Bogdan, V. Krajčí: Osnove robotike, Graphis, Zagreb, 2002.<br>F. Lamb: Industrial automation: hands-on. McGraw-Hill Education, 2013. |
| *1.12. Number of assigned reading copies with regard to the number of students currently attending the course* |

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| B. Siciliano, K. Oussama: Springer handbook of robotics. Springer, 2016. | 1 | |
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| *1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences* |
| Through the Institution's quality assurance system. |

| Basic description | | | |
|---|---|---|---|
| Course title | **Graduate Work** | | |
| Study programme | **Graduate University Study of Electrical Engineering** | | |
| Course status | compulsory | | |
| Year | **2.** | | |
| ECTS credits and teaching | ECTS student 's workload coefficient | 10 | |
| | Number of hours (L+E+S) | - | |

| 1. COURSE DESCRIPTION | | | | | | | |
|---|---|---|---|---|---|---|---|
| *1.1. Course objectives* | | | | | | | |
| Graduate work is an individual assignment and verification of student expertises, which should show the appropriate level of engineering skills for individually solving specific professional task. | | | | | | | |
| *1.2. Course enrolment requirements* | | | | | | | |
| Enrolled course from which the Graduate Work is selected. | | | | | | | |
| *1.3. Expected course learning outcomes* | | | | | | | |
| Apply acquired knowledge, expertises and skills of the content of Graduate Work associated course. Solve practical task. Acquire competence for individually solving specific professional task. | | | | | | | |
| *1.4. Course content* | | | | | | | |
| The content of the Graduate Work is based on the application of acquired knowledge from educational programs at the graduate university studies. Final thesis can be specified from a particular course specific professional content and exceptionally from course that belongs to the group of shared content, when it represents a broader entity with a particular course specific content of the studies. Student enrollers the Graduate Work by enrolling the last semester. Thesis of the Graduate Work is establishes by Commission for Graduate Works, based on suggestion of teacher who will mentor the Graduate Work. | | | | | | | |
| *1.5. Teaching methods* | ☐ lectures<br>☐ seminars and workshops<br>☐ exercises<br>☐ long distance education<br>☐ fieldwork | | | ☒ individual assignment<br>☐ multimedia and network<br>☐ laboratories<br>☒ mentorship<br>☐ other | | | |
| *1.6. Comments* | | | | | | | |
| *1.7. Student's obligations* | | | | | | | |
| Attending the consultation, individually solving task and writing the Graduate Work report. | | | | | | | |
| *1.8. Evaluation of student's work* | | | | | | | |
| Course attendance | | Activity/Participation | | Seminar paper | | Experimental work | |
| Written exam | | Oral exam | | Essay | | Research | |
| Project | | Sustained knowledge check | | Report | | Practice | |
| Portfolio | | Individual task solving | 8 | Final work in written form | 2 | | |
| *1.9. Procedure and examples of learning outcome assessment in class and at the final exam* | | | | | | | |

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|---|
| Assesses and evaluates the accuracy and completeness of a given task solving process, the Graduate Work written report, and its oral presentation |
| *1.10. Assigned reading (at the time of the submission of study programme proposal)* |
| |
| *1.11. Optional / additional reading (at the time of proposing study programme)* |
| |
| *1.12. Number of assigned reading copies with regard to the number of students currently attending the course* |

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
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| *1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences* |
| Through the Institution's quality assurance system. |

| Basic description | | |
|---|---|---|
| Course title | **High Voltage Engineering** | |
| Study programme | **Graduate University Study of Electrical Engineering** | |
| Course status | optional | |
| Year | **1.** | |
| ECTS credits and teaching | ECTS student 's workload coefficient | 5 |
| | Number of hours (L+E+S) | 30+30+0 |

| **1.COURSE DESCRIPTION** | | |
|---|---|---|
| *1.1. Course objectives* | | |
| Basic definitions and application of high voltage, and learning about the technology of insulation materials, test methods and modern methods of monitoring of the insulation system in operation. General competence will develop the ability to analyze and synthesize, teamwork, basic calculation skills and problem solving. | | |
| *1.2. Course enrolment requirements* | | |
| None. | | |
| *1.3. Expected course learning outcomes* | | |
| After passing the course, students will be able to do the following:<br>1. Appoint and differentiate the elements of the power system used for the transmission of electricity on high voltage<br>2. Define and describe the production and measurement of high voltage<br>3. Group and give examples of insulation on high voltage<br>4. Describe the different processes that lead to breakthrough HV insulation<br>5. Define insulation coordination and specify nominal and test voltages for individual voltage levels<br>6. Identify and classify the types of surges occurring in the power system<br>7. Describe the formation and propagation of traveling waves | | |
| *1.4. Course content* | | |
| Basic definitions and application of high voltage. Analytical methods and numerical methods for the calculation of the electric field. Materials in an electric field; dielectric losses and polarization. The electromagnetic field near HV lines and plants. Gases as insulators; ionization and deionization, electrical breakthrough. Pashens law. The origins and effects of impulse corona. Electric arc in circuit breakers; blowout of the electric arc. Fluid insulators; theory of electrical breakthrough, dielectric strength. A solid dielectrics; electrical, thermal and electromechanical breakthrough. Partial discharge. Production of high voltage. Measurement of high voltages. High voltage tests. Coordination of insulation in high voltage systems. | | |
| *1.5. Teaching methods* | ☒ lectures<br>☐ seminars and workshops<br>☒ exercises<br>☐ long distance education<br>☐ fieldwork | ☒ individual assignment<br>☒ multimedia and network<br>☒ laboratories<br>☐ mentorship<br>☐ other |
| *1.6. Comments* | | |
| *1.7. Student's obligations* | | |

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|---|
| Class attendance, laboratory practice, written exam. |
| *1.8. Evaluation of student's work* |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 2 | Activity/Participation | | Seminar paper | | Experimental work | |
| Written exam | 1 | Oral exam | 0.5 | Essay | | Research | |
| Project | | Sustained knowledge check | 1.5 | Report | | Practice | |
| Portfolio | | | | | | | |

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| *1.9. Procedure and examples of learning outcome assessment in class and at the final exam* |
| Attending lectures, auditory teaching, laboratory teaching, tests, written exam. |
| *1.10. Assigned reading (at the time of the submission of study programme proposal)* |
| Ivo Uglešić, Tehnika visokog napona, Zagreb, 2003. (skripta) |
| *1.11. Optional / additional reading (at the time of proposing study programme)* |
| High-Voltage Engineering: Fundamentals; E. Kuffel, W.S. Zaengl, J. Kuffel; Butterworth-Heinemann; 2001; ISBN: 0750636343 |
| *1.12. Number of assigned reading copies with regard to the number of students currently attending the course* |

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| Ivo Uglešić, Tehnika visokog napona, Zagreb, 2003. (skripta) | 5 | 22 |
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| *1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences* |
| Through the Institution's quality assurance system. |

| Basic description | | |
|---|---|---|
| Course title | **Man Machine Communication** | |
| Study programme | **Graduate University Study of Electrical Engineering** | |
| Course status | optional | |
| Year | **2.** | |
| ECTS credits and teaching | ECTS student 's workload coefficient | 5 |
| | Number of hours (L+E+S) | 30+30+0 |

**1. COURSE DESCRIPTION**

*1.1. Course objectives*

Introduce to students state of the art methods and procedures in pattern recognition and understanding systems.

*1.2. Course enrolment requirements*

None.

*1.3. Expected course learning outcomes*

The students will understand how to implement and develop pattern recognition and understanding computer systems.

*1.4. Course content*

Introduction to pattern recognition and understanding systems. Speech coding, sampling and processing procedures. Speech signal features. Short time spectral analysis of signals. Homomorphic signal analysis, cepstrum. Fundamental speech frequency estimation. Acoustic modeling using hidden Markov Models. Language resources, corpus, lexicons, speech databases. Language modeling. Speech recognition methods. Dialog modeling. Speech synthesis.

| | | |
|---|---|---|
| *1.5. Teaching methods* | ☒ lectures<br>☐ seminars and workshops<br>☒ exercises<br>☐ long distance education<br>☐ fieldwork | ☒ individual assignment<br>☐ multimedia and network<br>☐ laboratories<br>☐ mentorship<br>☐ other |
| *1.6. Comments* | | |

*1.7. Student's obligations*

Students have to attend to all course activities and work on projects.

*1.8. Evaluation of student's work*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 2 | Activity/Participation | | Seminar paper | | Experimental work | |
| Written exam | 1 | Oral exam | | Essay | | Research | |
| Project | 2 | Sustained knowledge check | | Report | | Practice | |
| Portfolio | | | | | | | |

*1.9. Procedure and examples of learning outcome assessment in class and at the final exam*

The presence to all course activities and work on projects will be evaluated.

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|---|
| *1.10. Assigned reading (at the time of the submission of study programme proposal)* |
| Nikola Pavešić: Raspoznavanje vzorcev, Založba FE in FRI Ljubljana, 2012. (in Slovenian) |
| *1.11. Optional / additional reading (at the time of proposing study programme)* |
| Richard O. Duda, Peter E. Hart, David G. Stork: Pattern Classification, Wiley-Interscience; 2nd edition, 2000. |
| *1.12. Number of assigned reading copies with regard to the number of students currently attending the course* |

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| Nikola Pavešić: Raspoznavanje vzorcev, Založba FE in FRI Ljubljana, 2012. (in Slovenian) | 1 | 50 |
| Richard O. Duda, Peter E. Hart, David G. Stork: Pattern Classification, Wiley-Interscience; 2nd edition, 2000. | 1 | 50 |
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| *1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences* |
| Faculty quality methods will be employed. |

| Basic description | | |
|---|---|---|
| Course title | **Mechatronic Systems** | |
| Study programme | **Graduate University Study of Electrical Engineering** | |
| Course status | optional | |
| Year | **2.** | |
| ECTS credits and teaching | ECTS student 's workload coefficient | 5 |
| | Number of hours (L+E+S) | 30+30+0 |

| 1. **COURSE DESCRIPTION** | | |
|---|---|---|
| *1.1. Course objectives* | | |
| Understanding of mechatronic systems components. Understanding of relationships between different parts of mechatronic system. Correlating of electrical engineering, electronics and computing. | | |
| *1.2. Course enrolment requirements* | | |
| None. | | |
| *1.3. Expected course learning outcomes* | | |
| Describing and reasoning of mechatronic principle. Describing of particular mechatronic systems and their meanings. Differencing components of mechatronic systems. Describing and explaining principles and characteristics of mechanical, hydraulic and pneumatic actuators. Describing of different sensors and their applications. Describing of electronic power converters and their algorithms for different mechatronic applications. Describing of modern electric machines and their control algorithms. Using and describing of mechatronic system design. | | |
| *1.4. Course content* | | |
| Definition and concept of mechatronic systems. Mechatronics in technical products, producing systems, process industry, robotics, transport. Components and interfaces of mechatronic systems. Mechanic, hydraulic and pneumatic components of mechatronic system. Actuators. Sensors. Mechatronic system design and modelling. Modern control algorithms for mechatronic systems. Mass reducing in mechatronic systems. Adaptive control. Review of intelligent control and their application. Expert systems, fuzzy logic, neural networks. Criteria for algorithm selection. Digital and analogue signal processing. Computing and communication systems. | | |
| *1.5. Teaching methods* | ☒ lectures<br>☐ seminars and workshops<br>☒ exercises<br>☐ long distance education<br>☐ fieldwork | ☒ individual assignment<br>☐ multimedia and network<br>☒ laboratories<br>☐ mentorship<br>☐ other |
| *1.6. Comments* | - | |
| *1.7. Student's obligations* | | |
| Course attendance, working reports | | |
| *1.8. Evaluation of student's work* | | |

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|---|---|---|---|---|---|---|---|
| Course attendance | 2 | Activity/Participation | | Seminar paper | 0.5 | Experimental work | |
| Written exam | 1 | Oral exam | | Essay | | Research | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Project | | Sustained knowledge check | 1 | Report | | Practice | |
| Portfolio | | Laboratory execises | 0.5 | | | | |

*1.9. Procedure and examples of learning outcome assessment in class and at the final exam*

Course attendance, activity, solving exams, independent learning.

*1.10. Assigned reading (at the time of the submission of study programme proposal)*

Lecture materials and lecture notes

*1.11. Optional / additional reading (at the time of proposing study programme)*

Bishop, R.H.: The Mechatronics Handbook, CRC Press, Washington, D.C., 2005
_: Fackunde Mechatronik, Verlag Europa-Lehrmittel, Haan-Gruiten, 2004.
Bose, B.K.: Modern Power Electronics and AC Drives, Prentice-Hall, 2002.
Kwang Hee Nam: AC Motor Control and Electrical Vehicle Applications, CRC Press; 1 edition, 2010

*1.12. Number of assigned reading copies with regard to the number of students currently attending the course*

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| | | 34 |
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*1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences*

Through the Institution's quality assurance system.

| Basic description | | |
|---|---|---|
| Course title | **Microwave Engineering** | |
| Study programme | **Graduate University Study of Electrical Engineering** | |
| Course status | optional | |
| Year | **1.** | |
| ECTS credits and teaching | ECTS student 's workload coefficient | 6 |
| | Number of hours (L+E+S) | 45+15+0 |

| 1. **COURSE DESCRIPTION** | | |
|---|---|---|
| *1.1. Course objectives* | | |
| Students will acquire knowledge of the nature of radio-wave communications and major components of radiocommunication systems, from the source to a receiver. The course will provide the knowledge of key principles, phenomena, techniques, and components of the system. | | |
| *1.2. Course enrolment requirements* | | |
| None. | | |
| *1.3. Expected course learning outcomes* | | |
| Apply decibels, nepers, and vector operators. Describe Maxwell's equations. Describe the wave equation and relevant coefficients. Analyze wave propagation through an unguided medium. Analyze a wave on the boundary of two media. Analyze wave propagation through a transmission line. Explain and apply the Smith chart. Analyze the S-parameters of a two-port network. Analyze and design circuits for impedance transformation. Explain power dividers. Design a microwave filtar. Describe and apply antenna parameters. Explain measurements of S-parameters and radiation pattern. Analyze a communication channel and the propagation effects. Analyze and design an RF link. Analyze the field value in a broadcast regime. Explain the intermodulation distortion and image frequency. | | |
| *1.4. Course content* | | |
| Electromagnetic spectrum. Types of electromagnetic waves. A basic scheme of a radiocommunication system. Decibels and nepers. Vector operators and applications. Maxwell's equations. Constitutive relations. Boundary conditions. Wave equations. Plane wave in various media. Perpendicular and oblique wave incidence on media boundary. Transmission line model. Various cases of transmission line loading. The Smith chart. S-parameters. Impedance transformation by an Lnetwork. Impedance transformation by stub. Quarter-wave impedance transformer. Binomial impedance transformer. Power dividers. Microwave filtar design. Fundamental antenna parameters. Antenna measurements. Communication channel and effects on wave propagation. RF link budget. An overview of propagation models for field prediction. Intermodulation distortion. Image frequency. | | |
| *1.5. Teaching methods* | ☒ lectures<br>☐ seminars and workshops<br>☒ exercises<br>☐ long distance education<br>☐ fieldwork | ☐ individual assignment<br>☐ multimedia and network<br>☐ laboratories<br>☐ mentorship<br>☐ other |
| *1.6. Comments* | | |
| *1.7. Student's obligations* | | |
| Class attendance, literature reading, class preparation, and continuous studying. | | |

| *1.8. Evaluation of student's work* | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 2 | Activity/Participation | | Seminar paper | | Experimental work | |
| Written exam | 1 | Oral exam | | Essay | | Research | |
| Project | | Sustained knowledge check | 3 | Report | | Practice | |
| Portfolio | | Homework | | | | | |

*1.9. Procedure and examples of learning outcome assessment in class and at the final exam*

Continuous knowledge examination (midterms) and final exam.

*1.10. Assigned reading (at the time of the submission of study programme proposal)*

D. M. Pozar, Microwave Engineering, 4th ed., Wiley, 2011.

*1.11. Optional / additional reading (at the time of proposing study programme)*

J. D. Parsons, *The Mobile Radio Propagation Channel*, 2nd ed, Wiley, 2000.
C. A. Balanis, *Antenna Theory: Analysis and Design*, 4th ed, Wiley, 2016.

*1.12. Number of assigned reading copies with regard to the number of students currently attending the course*

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| D. M. Pozar, *Microwave Engineering*, 4th ed., Wiley, 2011. | - | 35 |
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*1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences*

Through the Institution's quality assurance system.

| Basic description | | |
|---|---|---|
| Course title | **Numerical and Stochastic Mathematics** | |
| Study programme | **Graduate University Study of Electrical Engineering** | |
| Course status | compulsory | |
| Year | **1.** | |
| ECTS credits and teaching | ECTS student 's workload coefficient | 6 |
| | Number of hours (L+E+S) | 45+15+0 |

| 1. COURSE DESCRIPTION | | |
|---|---|---|
| *1.1. Course objectives* | | |
| Acquiring basic knowledge and skills in numerical and stochastic mathematics. | | |
| *1.2. Course enrolment requirements* | | |
| None. | | |
| *1.3. Expected course learning outcomes* | | |
| Recognize appropriate numerical methods for given simpler mathematical formulations of engineering problems. Correctly explain fundamental idea of particular computational methods. Correctly explain advantages and disadvantages of particular computational methods. Apply existing software to simpler problems. Write simple computer programs for particular computational methods by following instructions. Evaluate results of computational methods.<br>Define and interpret correctly random variables, interpret correctly and calculate means and variances. Describe some basic probability distributions, interpret correctly their meaning and use them in typical experiments. Define and interpret correctly basic concepts of random vectors. Define and explain correctly some basic concepts of stochastic processes and Markov chains. Express and understand basic results from Markov chain theory. Apply Markov chains in problem solving. | | |
| *1.4. Course content* | | |
| Numerical methods for solving nonlinear equations with one unknown.<br>Numerical methods for solving linear systems: direct and iterative methods.<br>Curve fitting: interpolation polynomial and interpolation splines, regression.<br>Numerical integration and differentiation.<br>Numerical methods for solving ordinary differential equations.<br>Random variables and standard distributions.<br>Random vectors.<br>Stochastic processes. Markov chains. | | |
| *1.5. Teaching methods* | ☒ lectures<br>☐ seminars and workshops<br>☒ exercises<br>☐ long distance education<br>☐ fieldwork | ☐ individual assignment<br>☐ multimedia and network<br>☒ laboratories<br>☐ mentorship<br>☐ other |
| *1.6. Comments* | | |
| *1.7. Student's obligations* | | |
| Course attendance, activity/participation, studying | | |

| 1.8. *Evaluation of student's work* | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 2 | Activity/Participation | | Seminar paper | | Experimental work | |
| Written exam | 0.5 | Oral exam | 0.5 | Essay | | Research | |
| Project | | Sustained knowledge check | 3 | Report | | Practice | |
| Portfolio | | | | | | | |

*1.9. Procedure and examples of learning outcome assessment in class and at the final exam*

Course attendance, activity, continuous knowledge testing (mid-term exams, tests, tests on computer), written and oral exam

*1.10. Assigned reading (at the time of the submission of study programme proposal)*

Chapra S. C., Channale R. P.: Numerical methods for engineers, McGrowHill Inc., 1988
Črnjarić-Žic N., Internal lecture notes with solved problems from Engineering statistics, Rijeka 2010. (in Croatian)
Elezović, N., Discrete probability, Random variables, Statistics and processes, Biblioteka Bolonja, Element, Zagreb 2007 . (in Croatian)

*1.11. Optional / additional reading (at the time of proposing study programme)*

Scitovski R.: Numerical mathematics, Sveuč. u Osijeku, Elektrotehnički fakultet, 1999. (in Croatian)
Leon-Garcia A., Probability, Statistics, and Random Processes for Electrical Engineering, Pearson Education, Inc., 2008.

*1.12. Number of assigned reading copies with regard to the number of students currently attending the course*

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| Chapra S. C., Channale R. P.: Numerical methods for engineers, McGrowHill Inc., 1988 | 15 | 82 |
| Črnjarić-Žic N., Internal lecture notes with solved problems from Engineering statistics, Rijeka 2010. (in Croatian) | 82 | 82 |
| Elezović, N., Discrete probability, Random variables, Statistics and processes, Biblioteka Bolonja, Element, Zagreb 2007 | 3 | 82 |

*1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences*

Through the Institution's quality assurance system.

| Basic description | | |
|---|---|---|
| Course title | **Optoelectronics** | |
| Study programme | **Graduate University Study of Electrical Engineering** | |
| Course status | optional | |
| Year | **2.** | |
| ECTS credits and teaching | ECTS student 's workload coefficient | 4 |
| | Number of hours (L+E+S) | 30+15+0 |

| 1. **COURSE DESCRIPTION** | | |
|---|---|---|
| *1.1. Course objectives* | | |
| Course focuses on the physics of the interaction of photons with semiconductor materials. The principles and design of semiconductor optoelectronic devices including light sources: light-emitting diodes (LED) and semiconductor lasers; photodetectors: photoconductors, photodiodes, phototransistors, CCDs, APSs and biosensors; photovoltaics: solar cells. The physics and technology of semiconductor optoelectronic devices and their applications are described. | | |
| *1.2. Course enrolment requirements* | | |
| None. | | |
| *1.3. Expected course learning outcomes* | | |
| Students are able to explain the semiconductor properties, mechanisms of light absorption and generation in semiconductors and their mathematical models, semiconductor with direct and indirect energy gap, heterojunctions and nanostructures. Obtain theoretical knowledge and develop skills to solve problems in the field of semiconductor and optoelectronics devices. Describe the behaviour and basics of numerical modelling of semiconductors and optoelectronics devices, such as sensors, detectors, light sources and solar cells. Solve problems and describe model of the image sensors, such as APS. Application of light source LED and photodiode for detection of light signal. Applied the solar cells as source of electrical energy for bias the photodiode. Distinguish the photodiode from solar cells behaviour. Describe CCD, APS and biosensor.<br>In experimental work in laboratory, as part of a project, the aim is, basing on the analysis, calculus and semiconductor discrete devices characterization, to design and develop the image sensor, test it and review it probable application. Solar cell characterisation, analysis and calculation of their parameters as a model of photovoltaics source. Participate as a member of a team-oriented design project. | | |
| *1.4. Course content* | | |
| Physics of semiconductors: crystal structure, energy diagram, free carrier concentration, ray optics, generation and recombination rate in semiconductors. Semiconductor devices: p-n junction, hetero-junctions. Photonics devices and sensors. Light source: Radiative transitions, LED, lasers; Detectors: Photoconductors, Photodiode, Avalanche photodiode, Phototransistors, Charge-coupled device CCD, CMOS sensors, APS sensors, biosensors, Solar Cells, Basic of Optoelectronics Technology. Basic of optoelectronic devices numerical modelling. | | |
| *1.5. Teaching methods* | ☒ lectures<br>☐ seminars and workshops<br>☒ exercises<br>☒ long distance education<br>☐ fieldwork | ☒ individual assignment<br>☒ multimedia and network<br>☒ laboratories<br>☐ mentorship<br>☐ other |
| *1.6. Comments* | | |

*1.7. Student's obligations*

Active course attendance and studying, homework and project.

*1.8. Evaluation of student's work*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 1.5 | Activity/Participation | | Seminar paper | | Experimental work | 0.5 |
| Written exam | 0.5 | Oral exam | 0.5 | Essay | | Research | |
| Project | 0.5 | Sustained knowledge check | 0.5 | Report | | Practice | |
| Portfolio | | | | | | | |

*1.9. Procedure and examples of learning outcome assessment in class and at the final exam*

Course attendance, activity, homework, continuous knowledge testing (two mid-term exams), written and oral exam.

*1.10. Assigned reading (at the time of the submission of study programme proposal)*

V. Gradišnik, Lecture and exercise published on the web every year.
S.M.Sze, Physics of Semiconductor Devices, New Jersey: J. Wiley &Sons, Inc. Publication, 2007.
Petar Kulišić, Jadranka Vuletin, Ivan Zulim, Solar Cells, Zagreb: Školska knjiga, 1994. (in Croatian)
S.L. Chuang, Physics of Photonics Devices 2nd Edition, Wiley, 2009, New Jersey, ISBN 978-0-470-29319-5
B.E.A. Saleh, M.C. Teich, Fundamentals of Photonics, 2nd Edition, Wiley, 2007, New Jersey, ISBN 978-0-471-35832-9
A.Kitai, Principles of Solar Cells, LEDs and Related Devices: The Role of the PN Junction, 2nd Edition,
Wiley & Sons, Inc. Publication, 2018, New Jersey, ISBN: 978-1-119-45100-6

*1.11. Optional / additional reading (at the time of proposing study programme)*

Stephen J. Fonash, Solar Cel Device Physics, Burlington, Kidlington, Oxford, Elsevier, 2010.
F. Graham Smith, Terry A. King, Dan Wilkins, Optics and Photonics: An Introduction, 2nd ed., Wiley & Sons, Inc. Publication, 2008, Chichester, ISBN 978-0-470-01783-8 – ISBN 978-0-470-01784-5
V. Gradišnik, D. Gumbarević, a-Si:H p-i-n Photodiode as a Biosensor, Advances in Photodetectors - Research and Applications, IntechOpen, 2019, London, doi:10.5772/intechopen.80503
H. Yu, M. Yan, X. Huang, CMOS Integrated Lab-on-a-Chip System for Personalized Biomedical Diagnosis, John Wiley & Sons Singapore, 2018, ISBN:9781119218326

*1.12. Number of assigned reading copies with regard to the number of students currently attending the course*

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| V. Gradišnik, Lecture and exercise published on the web every year. | web | 30 |
| S.M.Sze, K.K. Ng, Physics of Semiconductor Devices, 3nd Edition, Wiley, 2007, New Jersey, ISBN.13:978-0-471-14323-9 | 1 | 30 |
| Petar Kulišić, Jadranka Vuletin, Ivan Zulim, Solar Cells, Zagreb: Školska knjiga, 1994 (in Croatian) | 1 | 30 |
| S.L. Chuang, Physics of Photonics Devices 2nd Edition, Wiley, 2009, New Jersey, ISBN 978-0-470-29319-5 | 1 | 30 |
| B.E.A. Saleh, M.C. Teich, Fundamentals of Photonics, 2nd Edition, Wiley, 2007, New Jersey, ISBN 978-0-471-35832-9 | 1 | 30 |
| A.Kitai, Principles of Solar Cells, LEDs and Related Devices: The Role of the PN Junction, 2nd Edition, Wiley & Sons, Inc. Publication, 2018, New Jersey, ISBN: 978-1-119-45100-6 | 1 | 30 |

*1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences*

Through the Institution's quality assurance system

| Basic description | | |
|---|---|---|
| Course title | **Power Plants** | |
| Study programme | **Graduate University Study of Electrical Engineering** | |
| Course status | optional | |
| Year | **2.** | |
| ECTS credits and teaching | ECTS student 's workload coefficient | 4 |
| | Number of hours (L+E+S) | 30+30+0 |

| **1.COURSE DESCRIPTION** | | |
|---|---|---|
| *1.1. Course objectives* | | |
| Adoption of the theoretical knowledge and skills for solving technical problems in the field of design, operation and maintenance of power plants. | | |
| *1.2. Course enrolment requirements* | | |
| None. | | |
| *1.3. Expected course learning outcomes* | | |
| Describe and analyze the conversion of energy in power plants to produce electricity and heat. Describe and analyze the plant with steam and gas turbines. Develop energy balance and calculating efficiency of thermal power plants with steam and gas process. Analyze and explain the factors influencing efficiency of thermal power plants. Draw the basic scheme of the main types of thermal power plants. Describe and calculate the main components of thermal power plants (steam generators, turbines, condensers, regenerative water heaters, cooling towers, gas turbines, compressors, waste heat boiler). Describe the main influential factors when designing thermal power plant. Indicate and explain the operational problems that may arise in the operation of thermal power plants. Describe the main principles of good maintenance of thermal power plants. | | |
| *1.4. Course content* | | |
| Introduction to thermal power plants. Steam power plant. Utilization and fuel efficiency of steam power plants. Ways of increasing the efficiency of steam power plants. Steam plant for the combined production of electricity and heat. Steam generators. Heat balance, efficiency and fuel consumption in the steam generators. Steam turbines. The working principle of a steam turbine. Types of steam turbines. Losses and efficiency of steam turbines. Steam condensers. Regenerative water heaters. Cooling towers. Treatment of feed water in steam thermal power plants. Design of thermal power plants. Gas fired power plants. The main types of gas thermal power plants. Thermal power plants with a combined gas-steam process. Cogeneration thermal power plants. The main parts of a gas turbine plant. Nuclear power plant. Non-conventional power plants. | | |
| *1.5. Teaching methods* | ☒ lectures<br>☐ seminars and workshops<br>☒ exercises<br>☐ long distance education<br>☐ fieldwork | ☐ individual assignment<br>☐ multimedia and network<br>☐ laboratories<br>☐ mentorship<br>☐ other |
| *1.6. Comments* | | |
| *1.7. Student's obligations* | | |
| Course attendance, activity, studying | | |

| 1.8. *Evaluation of student's work* | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 2 | Activity/Participation | | Seminar paper | | Experimental work | |
| Written exam | | Oral exam | 1 | Essay | | Research | |
| Project | | Sustained knowledge check | 1 | Report | | Practice | |
| Portfolio | | | | | | | |

*1.9. Procedure and examples of learning outcome assessment in class and at the final exam*

Course attendance, activity, continuous knowledge testing (2 mid-term exams), written or oral exam.

*1.10. Assigned reading (at the time of the submission of study programme proposal)*

Prelec, Z.: Energetics in process industry (in Croatian), Školska knjiga, Zagreb, 1994.
Prelec, Z.: Summary of lectures, (pdf. on Faculty web)
El-Vakil, M.: Power plant technology, Mc Graw Hill Book Company, 1988.

*1.11. Optional / additional reading (at the time of proposing study programme)*

Požar, H.: Basis of energetics, 1st and 2nd part ( in Croatian), Školska knjiga Zagreb, 1976., 1978,

*1.12. Number of assigned reading copies with regard to the number of students currently attending the course*

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| Prelec, Z.: Energetics in process industry, Školska knjiga, Zagreb, 1994. (in Croatian) | 10 | 57 |
| | | |
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| | | |
| | | |

*1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences*

Through the Institution's system of quality control

| Basic description | | | |
|---|---|---|---|
| Course title | **Professional Practice II** | | |
| Study programme | **Graduate University Study of Electrical Engineering** | | |
| Course status | compulsory | | |
| Year | **1.** | | |
| ECTS credits and teaching | ECTS student 's workload coefficient | 5 | |
| | Number of hours (L+E+S) | - | |

| 1. COURSE DESCRIPTION | | |
|---|---|---|
| *1.1. Course objectives* | | |
| Student verifies and complements his own expertise, along with a comprehensive view of the work process. | | |
| *1.2. Course enrolment requirements* | | |
| None. | | |
| *1.3. Expected course learning outcomes* | | |
| Apply acquired knowledge and skills from studied courses professional content. Gain working process experience. Develop and further improve competence for solving specific professional engineering problems. | | |
| *1.4. Course content* | | |
| Industrial practice within Graduate University Study of Naval Architecture is carried out individually in work organization that is engaged in the student's field of study, and with activities in accordance with the Industrial Practice Rules and Study Program curriculum. Within such practice, student is familiarized with the corresponding jobs that are studied through programs of education, with the task of verifying and complementing their own expertise, along with a comprehensive view of the work process. | | |
| *1.5. Teaching methods* | ☐ lectures<br>☐ seminars and workshops<br>☐ exercises<br>☐ long distance education<br>☒ fieldwork | ☐ individual assignment<br>☐ multimedia and network<br>☐ laboratories<br>☐ mentorship<br>☐ other |
| *1.6. Comments* | | |
| *1.7. Student's obligations* | | |
| Conducting professional practice in duration of 15 working days, or 120 hours, and writing the corresponding report. | | |

*1.8. Evaluation of student's work*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | | Activity/Participation | | Seminar paper | | Experimental work | |
| Written exam | | Oral exam | | Essay | | Research | |
| Project | | Sustained knowledge check | | Report | 1 | Practice | 4 |
| Portfolio | | | | | | | |

*1.9. Procedure and examples of learning outcome assessment in class and at the final exam*

Assesses and evaluates student work and dedication, and written report.

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| *1.10. Assigned reading (at the time of the submission of study programme proposal)* |
| |
| *1.11. Optional / additional reading (at the time of proposing study programme)* |
| |
| *1.12. Number of assigned reading copies with regard to the number of students currently attending the course* |

| *Title* | *Number of copies* | *Number of students* |
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| *1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences* |
| Through the Institution's quality assurance system. |

| Basic description | | |
|---|---|---|
| Course title | **Project I** | |
| Study programme | **Graduate University Study of Electrical Engineering** | |
| Course status | optional | |
| Year | **1.** | |
| ECTS credits and teaching | ECTS student 's workload coefficient | 5 |
| | Number of hours (L+E+S) | 0+30+0 |

| 1. **COURSE DESCRIPTION** | | | | | | | |
|---|---|---|---|---|---|---|---|
| *1.1. Course objectives* | | | | | | | |
| Application of acquired knowledge and skills to solve practical problems in the field of associated course from which the Project I is elected. | | | | | | | |
| *1.2. Course enrolment requirements* | | | | | | | |
| Enrolled course from which the Project I is elected. | | | | | | | |
| *1.3. Expected course learning outcomes* | | | | | | | |
| Apply the knowledge and skills from professional content of the associated course. Solve practical task. Acquire competence for individually solving specific professional tasks. | | | | | | | |
| *1.4. Course content* | | | | | | | |
| Chosen chapter of associated course from which the project was elected. | | | | | | | |
| *1.5. Teaching methods* | ☐ lectures<br>☐ seminars and workshops<br>☐ exercises<br>☐ long distance education<br>☐ fieldwork | | | ☒ individual assignment<br>☐ multimedia and network<br>☐ laboratories<br>☒ mentorship<br>☐ other | | | |
| *1.6. Comments* | | | | | | | |
| *1.7. Student's obligations* | | | | | | | |
| Attending the consultation, individually solving task and writing the project report. | | | | | | | |
| *1.8. Evaluation of student's work* | | | | | | | |
| Course attendance | | Activity/Participation | | Seminar paper | | Experimental work | |
| Written exam | | Oral exam | | Essay | | Research | |
| Project | 2 | Sustained knowledge check | | Report | | Practice | |
| Portfolio | | Individual task solving | 3 | | | | |
| *1.9. Procedure and examples of learning outcome assessment in class and at the final exam* | | | | | | | |
| Assesses and evaluates the accuracy and completeness of the project task solution and its presentation. | | | | | | | |
| *1.10. Assigned reading (at the time of the submission of study programme proposal)* | | | | | | | |
| References listed for the associated course from which the Project I is elected. | | | | | | | |

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| *1.11. Optional / additional reading (at the time of proposing study programme)* |
| References listed for the associated course from which the Project I is elected. |
| *1.12. Number of assigned reading copies with regard to the number of students currently attending the course* |

| *Title* | *Number of copies* | *Number of students* |
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| *1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences* |
| Through the Institution's quality assurance system. |

| Basic description | | |
|---|---|---|
| Course title | **Project II** | |
| Study programme | **Graduate University Study of Electrical Engineering** | |
| Course status | optional | |
| Year | **2.** | |
| ECTS credits and teaching | ECTS student 's workload coefficient | 5 |
| | Number of hours (L+E+S) | 0+30+0 |

| 1. **COURSE DESCRIPTION** | | |
|---|---|---|
| *1.1. Course objectives* | | |
| Application of acquired knowledge and skills to solve practical problems in the field of associated course from which the Project II is elected. | | |
| *1.2. Course enrolment requirements* | | |
| Enrolled course from which the Project II is elected. | | |
| *1.3. Expected course learning outcomes* | | |
| Apply the knowledge and skills from professional content of the associated course. Solve practical task. Acquire competence for individually solving specific professional tasks. | | |
| *1.4. Course content* | | |
| Chosen chapter of associated course from which the project was elected. | | |
| *1.5. Teaching methods* | ☐ lectures<br>☐ seminars and workshops<br>☐ exercises<br>☐ long distance education<br>☐ fieldwork | ☒ individual assignment<br>☐ multimedia and network<br>☐ laboratories<br>☒ mentorship<br>☐ other |
| *1.6. Comments* | | |
| *1.7. Student's obligations* | | |
| Attending the consultation, individually solving task and writing the project report. | | |
| *1.8. Evaluation of student's work* | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | | Activity/Participation | | Seminar paper | | Experimental work | |
| Written exam | | Oral exam | | Essay | | Research | |
| Project | 2 | Sustained knowledge check | | Report | | Practice | |
| Portfolio | | Individual task solving | 3 | | | | |

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|---|
| *1.9. Procedure and examples of learning outcome assessment in class and at the final exam* |
| Assesses and evaluates the accuracy and completeness of the project task solution and its presentation. |
| *1.10. Assigned reading (at the time of the submission of study programme proposal)* |
| References listed for the associated course from which the Project II is elected. |

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|---|
| *1.11. Optional / additional reading (at the time of proposing study programme)* |
| References listed for the associated course from which the Project II is elected. |
| *1.12. Number of assigned reading copies with regard to the number of students currently attending the course* |

| *Title* | *Number of copies* | *Number of students* |
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| *1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences* |
| Through the Institution's quality assurance system. |

| Basic description | | | |
|---|---|---|---|
| Course title | **Protection and Automation of Electrical Installations** | | |
| Study programme | **Graduate University Study of Electrical Engineering** | | |
| Course status | optional | | |
| Year | **2.** | | |
| ECTS credits and teaching | ECTS student 's workload coefficient | 5 | |
| | Number of hours (L+E+S) | 30+45+0 | |

| 1. **COURSE DESCRIPTION** | | |
|---|---|---|
| *1.1. Course objectives* | | |
| The course is a professional discipline for all the students of the electric power system studies. The goal is to introduce the students to electrical protectionas and automation in electric power plants as well as introduce the students to secondary systems. | | |
| *1.2. Course enrolment requirements* | | |
| None. | | |
| *1.3. Expected course learning outcomes* | | |
| The physical image of power system operation during faults and disturbances. Ability to solve the given problems in order to determine setting of protection in electric power system. Define basic concepts and terminology. Describe electromechanical, static and numeric relays. Describe types of protection and explain where they are used. Analyse testing and commissioning. Set relay protection. Analyse numeric protection algorithms. | | |
| *1.4. Course content* | | |
| Definitions and terminology. Electromechanical, static and numeric relays. Overcurrent protection. Distance protection. Automatic reclosing. Protection of busbars. Protection of power transformers. Protection of generators and generator-transformer blocks. Protection of industrial electric power system. Testing and commissioning. Coordinated systems for protection and control of plants. Communication inside plant. Schemes of connections of numeric distant relays. Current and voltage measuring transformers. Numeric distant relays and fault locators. Numeric protection algorithms. Adaptive protection. Recording and analysis of faults. Application of expert systems in electric power system protection. Tendency of relay protection development. | | |
| *1.5. Teaching methods* | ☒ lectures<br>☒ seminars and workshops<br>☒ exercises<br>☐ long distance education<br>☒ fieldwork | ☐ individual assignment<br>☐ multimedia and network<br>☒ laboratories<br>☐ mentorship<br>☐ other |
| *1.6. Comments* | | |
| *1.7. Student's obligations* | | |
| Course attendance, activity, seminar paper, studying. | | |
| *1.8. Evaluation of student's work* | | |

| Course attendance | 2.5 | Activity/Participation | | Seminar paper | 0.5 | Experimental work | |
|---|---|---|---|---|---|---|---|

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|---|---|---|---|---|---|---|---|
| Written exam | 0.5 | Oral exam | | Essay | | Research | |
| Project | | Sustained knowledge check | 1.5 | Report | | Practice | |
| Portfolio | | | | | | | |

*1.9. Procedure and examples of learning outcome assessment in class and at the final exam*

Course attendance, activity, seminar paper, continuous knowledge testing (two mid-term exams), written exam.

*1.10. Assigned reading (at the time of the submission of study programme proposal)*

F. Božuta:Automatic protection devices in electrical power facilities, Svetlost, Sarajevo
H. Požar: High-voltage switchgear, Tehnička knjiga, Zagreb

*1.11. Optional / additional reading (at the time of proposing study programme)*

Electricity Training Association: Power system protection. Volume 1-4, IEE, Electricity Association Services Ltd., London, 1995
J. L. Blackburn: Protective Relaying; Principles and Applications, Marcel Dekker, Inc. New York, 1998

*1.12. Number of assigned reading copies with regard to the number of students currently attending the course*

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| F. Božuta: Automatic protection devices in electrical power facilities, Svetlost, Sarajevo | 2 | 20 |
| H. Požar: High-voltage switchgear, Tehnička knjiga, Zagreb (in Croatian) | 1 | 20 |

*1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences*

Through the Institution’s quality assurance system.

| Basic description | | |
|---|---|---|
| Course title | **Statistical Signal Analysis** | |
| Study programme | **Graduate University Study of Electrical Engineering** | |
| Course status | optional | |
| Year | **2.** | |
| ECTS credits and teaching | ECTS student 's workload coefficient | 6 |
| | Number of hours (L+E+S) | 45+15+0 |

| **1.COURSE DESCRIPTION** | | |
|---|---|---|
| *1.1. Course objectives* | | |
| Understand the concept of random signals, their time and frequency representations, and effects of linear time-invariant systems on random signals. Develop problem-solving skills, analysis and synthesis skills. | | |
| *1.2. Course enrolment requirements* | | |
| None. | | |
| *1.3. Expected course learning outcomes* | | |
| Define random signals in time and frequency domains. Define basic models for random signals characterisation. Analyse effects of linear time-invariant systems on random signals both in time and frequency. Apply learnt methods and techniques to signal detection, signal estimation, and filtering problems. | | |
| *1.4. Course content* | | |
| Statistical characterisation of random signals. Single and multiple random signals analysis. Stationarity and ergodicity of random signals. Correlation function. Power spectral density. Stationary random signals in linear time-invariant systems. Applications in signal filtering, detection, and estimation. | | |
| *1.5. Teaching methods* | ☒ lectures<br>☐ seminars and workshops<br>☒ exercises<br>☐ long distance education<br>☐ fieldwork | ☒ individual assignment<br>☐ multimedia and network<br>☐ laboratories<br>☐ mentorship<br>☐ other |
| *1.6. Comments* | - | |
| *1.7. Student's obligations* | | |
| Course attendance, project work, individual studying. | | |
| *1.8. Evaluation of student's work* | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 2 | Activity/Participation | | Seminar paper | | Experimental work | |
| Written exam | 1 | Oral exam | | Essay | | Research | |
| Project | 1 | Sustained knowledge check | 2 | Report | | Practice | |
| Portfolio | | | | | | | |

| *1.9. Assessment and evaluation of student's work during classes and on final exam* |
|---|
| Written tests, project report, written exam. |

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|---|---|---|
| *1.10. Assigned reading (at the time of the submission of study programme proposal)* | | |
| S. M. Kay: *Intuitive Probability and Random Processes using MATLAB*, Springer, 2006. | | |
| *1.11. Optional / additional reading (at the time of proposing study programme)* | | |
| M. Barkat: *Signal Detection and Estimation*, Artech House, 2005.<br>S. Engelberg: *Random Signals and Noise: A Mathematical Introduction*, CRC Press, 2007.<br>H. P. Hsu: *Probability, Random Variables, and Random Processes*, 3/E, McGraw-Hill, 2014.<br>D. G. Manolakis, V. K. Ingle, and S. M. Kogon: *Statistical and Adaptive Signal Processing: Spectral Estimation, Signal Modeling, Adaptive Filtering and Array Processing*, Artech House, 2005.<br>W. A. Woyczynski: *A First Course in Statistics for Signal Analysis*, Birkhaeuser, 2006. | | |
| *1.12. Number of assigned reading copies with regard to the number of students currently attending the course* | | |
| *Title* | *Number of copies* | *Number of students* |
| S. M. Kay: *Intuitive Probability and Random Processes using MATLAB*, Springer, 2006. | 1 | 40 |
| *1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences* | | |
| Through the Institution's quality assurance system. | | |

| Basic description | | | |
|---|---|---|---|
| Course title | **Transmission and Distribution of Electrical Energy** | | |
| Study programme | **Graduate University Study of Electrical Engineering** | | |
| Course status | optional | | |
| Year | **1.** | | |
| ECTS credits and teaching | ECTS student 's workload coefficient | 6 | |
| | Number of hours (L+E+S) | 45+30+0 | |

| 1. **COURSE DESCRIPTION** | | |
|---|---|---|
| *1.1. Course objectives* | | |
| Determination of mechanical and electrical parameters of overhead electrical lines and underground cables. The ability to solve the problems of transmission and distribution of electrical energy in electrical power networks. | | |
| *1.2. Course enrolment requirements* | | |
| None. | | |
| *1.3. Expected course learning outcomes* | | |
| Describe the characteristics of overhead electrical lines and underground cables. Perform the mechanical calculation of overhead electrical lines. Perform the calculation for selecting the optimal cross-section of underground cables. Perform the calculation of the line parameters of electrical power networks. Define the equivalent models of the electrical power network lines. Perform the calculation of the transmission of electrical power and energy. Analyse the electrical conditions of electrical power network lines. Analyse the transient states of electrical power network lines. Describe the characteristics of electrical distribution network lines. Perform the calculation of electrical parameters in distribution networks. Analyse the quality of electrical energy. Analyse the consumer electrical facilities and installations. Perform the calculation of electrical parameters of consumer electrical facilities and installations. | | |
| *1.4. Course content* | | |
| The history of electrification and the development of the electrical energy application. The transmission and distribution power systems. The constructional characteristics of overhead electrical lines. The mechanical calculation of overhead electrical lines. Underground electrical cables. Electrical parameters of the power lines. Symetrical components and the parameters for non-symetrical operational states. The teory of electrical energy transmission. Equivalent models of electrical power network lines. Determination of the voltage and current along the electrical line. Transformers and generators inclusion and modeling in the transmission of electrical energy. The teory of travelling waves on long electrical lines. The problems of economical transmission of electrical energy. The selection of voltage and cross-section of the electrical lines. The DC transmission of electrical energy. Characteristics of medium voltage and low voltage power networks. Determination of electrical parameters in meshed and radial distribution networks. Consumer electrical facilities and installations. The future of transmission and distribution of electrical energy. | | |
| *1.5. Teaching methods* | ☒ lectures<br>☐ seminars and workshops<br>☒ exercises<br>☐ long distance education<br>☐ fieldwork | ☒ individual assignment<br>☐ multimedia and network<br>☐ laboratories<br>☐ mentorship<br>☐ other |
| *1.6. Comments* | | |

| *1.7. Student's obligations* | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance, activity, homework, studying. | | | | | | | |
| *1.8. Evaluation of student's work* | | | | | | | |
| Course attendance | 2.5 | Activity/Participation | | Seminar paper | | Experimental work | |
| Written exam | 1 | Oral exam | 0.5 | Essay | | Research | |
| Project | | Sustained knowledge check | 1.5 | Report | | Practice | |
| Portfolio | | Homework | 0.5 | | | | |

| *1.9. Procedure and examples of learning outcome assessment in class and at the final exam* |
|---|
| Course attendance, activity, homework – construction projects, continuous knowledge testing (three mid-term exams, four unannounced tests), written and oral exam. |
| *1.10. Assigned reading (at the time of the submission of study programme proposal)* |
| M. Ožegović, K. Ožegović: Electric Power Networks I-VI, FESB Split, 1996.-2008.<br>Course materials in electronic form. |
| *1.11. Optional / additional reading (at the time of proposing study programme)* |
| J. Arrillaga, C. P. Arnold: Computer Analysis of Power Systems, John Wiles & Sons, 1995.<br>E. B. Kurtz, T. M. Shoemaker, J. E. Mack: The Lineman's and Cableman's Handbook, McGraw-Hill, 2004. |
| *1.12. Number of assigned reading copies with regard to the number of students currently attending the course* |

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| M. Ožegović, K. Ožegović: Electric Power Networks, I-VI, FESB Split, 1996.-2008.(in Croatian) | 8 | 34 |

| *1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences* |
|---|
| Through the Institution's quality assurance system. |

| Basic description | | |
|---|---|---|
| Course title | **Urban Energy Systems** | |
| Study programme | **Graduate University Study of Electrical Engineering** | |
| Course status | optional | |
| Year | **2.** | |
| ECTS credits and teaching | ECTS student ‘s workload coefficient | 5 |
| | Number of hours (L+E+S) | 30+30+0 |

| **1.COURSE DESCRIPTION** | | |
|---|---|---|
| *1.1. Course objectives* | | |
| Understanding the concept of urban energy systems. Acquiring theoretical fundamentals as well as practical knowledge in solving problems regarding automatisation, energy system and process analysis. | | |
| *1.2. Course enrolment requirements* | | |
| None. | | |
| *1.3. Expected course learning outcomes* | | |
| Describe the role and structure of automatisation in an energy system. Define basic principles for improving system efficiency and reliability. Explain the concept of an urban energy system (UES). Describe the role and elements of SCADA systems in UES. Define elements, possibilities and development models of UES. Define possibilities for implementation of new technical solutions in creating smart cities in practice. Define components and possibilities for practical development of a syncity system. Explain the service network design model and its application in a distributed UES. | | |
| *1.4. Course content* | | |
| Energy system overview. Introduction to process automatisation. Reasons, principles and advantages of automatisation. Levels of process control. Automatisation functions, examples, structures. Elements, evolution and role of SCADA. EMS application and analysis. Models and possibilities for production control. DA/DMS systems in practice. DMS; OMS; CIS; GIS; AMS; AMI. Elements, application and development of distributed sources of energy and distributed energy systems. Distributed sources of electricity and electricity storage. Smart distribution, demand-side management and demand response. HEM; microgrid. Concepts, elements and development models of UES. Integrated models of urban infrastructure; LU-T models. Definitions and components of a syncity system. Application and case study of syncity in practice. AMMUA concept; IMA approach to modelling. RTN model and its use in practice. Service network model design. Concept, elements and development of smart cities. Implementation possibilities of new technical solutions in EUS modelling. | | |
| *1.5. Teaching methods* | ☒ lectures<br>☐ seminars and workshops<br>☒ exercises<br>☐ long distance education<br>☒ fieldwork | ☒ individual assignment<br>☐ multimedia and network<br>☐ laboratories<br>☐ mentorship<br>☐ other |
| *1.6. Comments* | | |
| *1.7. Student’s obligations* | | |
| Course attendance, project, studying. | | |
| *1.8. Evaluation of student’s work* | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 2 | Activity/Participation | 0.5 | Seminar paper | 1 | Experimental work | |
| Written exam | 1 | Oral exam | 0.5 | Essay | | Research | |
| Project | | Sustained knowledge check | | Report | | Practice | |
| Portfolio | | | | | | | |

*1.9. Procedure and examples of learning outcome assessment in class and at the final exam*

Course attendance, class participation, seminar, written and oral exam.

*1.10. Assigned reading (at the time of the submission of study programme proposal)*

Thomas, M. S., McDonald, J. D.: Power System SCADA and Smart Grids, CRC Press, USA, 2015.
Keirstead, J., Shah, N.: Urban Energy Systems, Routledge, London, 2013.

*1.11. Optional / additional reading (at the time of proposing study programme)*

Sioshansi, F. P.: Smart Grid, Integrating Renewable, Distributed & Efficient Energy, AP-Elsevier, 2012.
Chaouchi, H.: Internet of Things, Wiley, London, 2010.

*1.12. Number of assigned reading copies with regard to the number of students currently attending the course*

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| Thomas, M. S., McDonald, J. D.: Power System SCADA and Smart Grids,CRC Press, USA,2015. | 0 | 30 |
| Keirstead, J., Shah, N.: Urban Energy Systems, Routledge, London, 2013. | 0 | 30 |
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*1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences*

Through the Institution's quality assurance system.