



University of Rijeka
Faculty of Engineering



**CURRICULUM
GRADUATE UNIVERSITY STUDY OF ELECTRICAL ENGINEERING**

Rijeka, May 2016

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	IT	dT	L+T		
	Numerical and Stochastic Mathematics	2		2		4	6	
	Control of Electrical Drives	3		1		4	6	
Subjects from elective group Automation:								
	Fundamentals of Robotics	3		1		4	6	
	Assistive Technology	2			2	4	6	
	Radiocommunications	3	1			4	6	
Subjects from elective group Power Engineering:								
	Theoretical Electrical Engineering	2	2			4	6	
	Transmission and Distribution of Electrical Energy	3	1		1	5	6	
	Driving and Operating Engines	3	1			4	6	
TOTAL							21	30

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

2. semester								
	Subject title	Hours / week					ECTS	
		L	aT	IT	dT	L+T		
	Project I ¹				2	2	5	
	Free Elective Subject I ²					4	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	2	2			4	5	
	Electric Power Substation Design	3	1	1		5	5	
	Numerical Analysis in Electromagnetism	2		1		3	5	
TOTAL							18	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: Assistive Technology, Automated Instrumentation, Fundamentals of Robotics, Radiocommunications

Elective group Power Engineering: Electric Power Plants, Electric Power Substation Design, Numerical Analysis in Electromagnetism, Theoretical Electrical Engineering, Transmission and Distribution of Electrical Energy

3. semester							
	Subject title	Hours / week					ECTS
		L	aT	IT	dT	L+T	
	Project II ³				2	2	5
	Elective Subject I					4	5
	Free Elective Subject II ⁴					4	5
Subjects from elective group Automation:							
	Mechatronic Systems	2	1	1		4	5
	Automation of Plants and Processes	2		2		4	6
	Digital Signal Processing	3	1			4	5
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						22	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, Radiocommunications

Elective group Power Engineering: Electric Power Plants, Electric Power Systems, Electric Power System Management, Electric Power Substation Design, Numerical Analysis in Electromagnetism, Protection and Automation of Electrical Installations, Theoretical Electrical Engineering, Transmission and Distribution of Electrical Energy

Elective Subject I							
	Subject title	Hours / week					ECTS
		L	aT	IT	dT	L+T	
Subjects from elective group Automation:							
	Optoelectronics	2	1			3	4
	Power Plants	2	2			4	4
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	IT	dT	L+T	
	Free Elective Subject III ⁵ Graduate Work					4	5 10
Subjects from elective group Automation:							
	Evolutionary Robotics	2	1	1		4	5
	Elective Subject II					4	5
	Elective Subject III					4	5
Subjects from elective group Power Engineering:							
	High Voltage Engineering	2	2			4	5
	Electricity Market	2	2			4	5
	Elective Subject II					4	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	IT	dT	L+T	
Subjects from elective group Automation:							
	Digital Image Processing	2	2			4	6
	Man Machine Communication	2	2			4	5
	Fundamentals of Statistical Signal Processing	3	1			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 76	ECTS 120
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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 skills 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:
Distinguish signals in time and frequency domain. Apply basic mathematical operations on time domain signals. Apply Fourier transform and inverse Fourier transform. Describe linear systems and idealized systems. Distinguish 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. Describe 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, Caue. 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

- | | |
|--------------------------------------------------|------------------------------------------------------------|
| <input checked="" type="checkbox"/> lectures | <input checked="" type="checkbox"/> individual assignment |
| <input type="checkbox"/> seminars and workshops | <input checked="" type="checkbox"/> multimedia and network |
| <input checked="" type="checkbox"/> exercises | <input checked="" type="checkbox"/> laboratories |
| <input type="checkbox"/> long distance education | <input type="checkbox"/> mentorship |
| <input type="checkbox"/> fieldwork | <input type="checkbox"/> 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. Assessment and evaluation of student's work during classes and on 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)

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

N. Stojković, V. Naglič, 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

<i>Title</i>	<i>Number of copies</i>	<i>Number of students</i>
N. Stojković, N. Mijat: Analog Signal Processing, Tehnički fakultet, Rijeka, 2005. (in Croatian)	6	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	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

2. COURSE DESCRIPTION

1.1. Course objectives

Adoption of theoretical and practical knowledge on the application of advanced algorithms in complex production 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 Support Vector Machines and machine learning. Identify and analyze the theory of games. Apply artificial intelligence in optimization problems. Analyze systems of learning and visual recognition. Apply 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. History overview, what is coming next. Problem-solving methodology. Knowledge and reasoning; Knowledge-Based Information Systems. Uncertain knowledge and reasoning. Artificial Neural Networks. Evolutionary Computing; Genetic Algorithms. Fuzzy Logic. Support Vector Machines. Expert systems. Machine learning; Learning from Observations, Learning in Neural and Belief Networks, Reinforcement Learning, Knowledge in Learning. Game theory; complex multi-agent systems, Autonomous Intelligent Agent. Data Mining. Application of artificial intelligence; Optimization and planning of real life problems, Learning systems, Vision recognition systems, AI systems in robotics, Autonomous agents for collaborative behavior, Game theory in economic systems, Banking application, Language processing and recognition, Social simulations.

1.5. Teaching methods

- | | |
|--------------------------------------------------|-----------------------------------------------------------|
| <input checked="" type="checkbox"/> lectures | <input checked="" type="checkbox"/> individual assignment |
| <input type="checkbox"/> seminars and workshops | <input type="checkbox"/> multimedia and network |
| <input checked="" type="checkbox"/> exercises | <input type="checkbox"/> laboratories |
| <input type="checkbox"/> long distance education | <input type="checkbox"/> mentorship |
| <input type="checkbox"/> fieldwork | <input type="checkbox"/> 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	1.5	Oral exam	1	Essay		Research	
Project	1	Sustained knowledge check		Report		Practice	
Portfolio							

1.9. Assessment and evaluation of student's work during classes and on 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)

Bramer, M., Devedzic, I, 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.

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.

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

<i>Title</i>	<i>Number of copies</i>	<i>Number of students</i>
Bramer, M., Devedzic, I, 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	1.	
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 technology for individuals with disability. Computer applications and user interfaces for individuals with disability. Voice interactive systems. Home automation. Ambient intelligence. Design for all. Assistive robotics. Mobility of a disabled person.

1.5. Teaching methods

- | | |
|------------------------------------------------------------|------------------------------------------------------------|
| <input checked="" type="checkbox"/> lectures | <input checked="" type="checkbox"/> individual assignment |
| <input checked="" type="checkbox"/> seminars and workshops | <input checked="" type="checkbox"/> multimedia and network |
| <input type="checkbox"/> exercises | <input type="checkbox"/> laboratories |
| <input type="checkbox"/> long distance education | <input type="checkbox"/> mentorship |
| <input checked="" type="checkbox"/> fieldwork | <input type="checkbox"/> 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. Assessment and evaluation of student's work during classes and on 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 Jersey.
 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

<i>Title</i>	<i>Number of copies</i>	<i>Number of students</i>
Helal, A. et al. (2008). The Engineering Handbook of Smart Technology for Aging, Disability and Independence, Wiley-Interscience, Hoboken, New Jersey.	1	10

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:

1. Describe static and dynamic errors of operational amplifiers
2. Analyze measurement amplifiers
3. Describe transfer function of A/D and D/A converters
4. Describe working principles of different types of A/D converters
5. Select the appropriate type of A/D converter for different measurement problems.
6. Describe the working principles of signal sources and user interfaces
7. Implement virtual instrument
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	<input checked="" type="checkbox"/> lectures	<input checked="" type="checkbox"/> individual assignment
	<input type="checkbox"/> seminars and workshops	<input type="checkbox"/> multimedia and network
	<input type="checkbox"/> exercises	<input checked="" type="checkbox"/> laboratories
	<input type="checkbox"/> long distance education	<input type="checkbox"/> mentorship
	<input type="checkbox"/> fieldwork	<input type="checkbox"/> 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. Assessment and evaluation of student's work during classes and on 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

<i>Title</i>	<i>Number of copies</i>	<i>Number of students</i>
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	6
	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 synthesize 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. Synthesizing 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 programming 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

- | | |
|--------------------------------------------------|--------------------------------------------------|
| <input checked="" type="checkbox"/> lectures | <input type="checkbox"/> individual assignment |
| <input type="checkbox"/> seminars and workshops | <input type="checkbox"/> multimedia and network |
| <input checked="" type="checkbox"/> exercises | <input checked="" type="checkbox"/> laboratories |
| <input type="checkbox"/> long distance education | <input type="checkbox"/> mentorship |
| <input type="checkbox"/> fieldwork | <input type="checkbox"/> 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	2	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.
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

<i>Title</i>	<i>Number of copies</i>	<i>Number of students</i>
Automation of Plants and Processes – lectures (script available for copying in first week of teaching) (in Croatian)		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	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 electric servo drives. Industrial applications of sensors. Getting acquainted with commercial usage of power electronics and microcomputers.

1.2. Course enrolment requirements

None.

1.3. Expected course learning outcomes

Description of dynamic models of specific drives, Building simulation models of controlled drives, Distinguish classical and new drive models, Analyse control models of drives, Reasoned selection of adequate drives, Description of control requirements and microprocessor architecture for different drives, Describe the modulation procedures in a converter

1.4. Course content

Realisation of a current and voltage power supply for electrical drives. Vector model of an asynchronous drive in the stator and rotor coordinate system. Comparative analysis of a DC machine model with separate exciter field and an asynchronous machine. Vector current and voltage models of an asynchronous drive in the coordinate system of the rotor field. Dynamic analysis of the working principle of an asynchronous drive. Detection methods of the field coordinate system via available parameter measurement. Comparative analysis of control of a DC machine with separate exciter field and an asynchronous machine in the field coordinate system. Current, voltage and position (speed) measurements in electrical drives. Drives with electronically commutated, reluctance and stepper motors. Direct torque control (DTC). Microcomputers in electrical drives.

1.5. Teaching methods

- | | |
|--------------------------------------------------|-----------------------------------------------------------|
| <input checked="" type="checkbox"/> lectures | <input checked="" type="checkbox"/> individual assignment |
| <input type="checkbox"/> seminars and workshops | <input type="checkbox"/> multimedia and network |
| <input checked="" type="checkbox"/> exercises | <input checked="" type="checkbox"/> laboratories |
| <input type="checkbox"/> long distance education | <input type="checkbox"/> mentorship |
| <input type="checkbox"/> fieldwork | <input type="checkbox"/> 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. Assessment and evaluation of student's work during classes and on final exam

Course attendance, activities in class, sustained knowledge checks (two tests), written and oral exam

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

V. Ambrožič: Modern Control of AC Drives, Fakulteta za elektrotehniko, Ljubljana, 1996. (in Slovenian)

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

W. Leonhard: Control of Electrical Drives, Springer Verlag, 1996.

B. K. Bose: Modern Power Electronics and AC Drives, Prentice Hall, 2002.

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

<i>Title</i>	<i>Number of copies</i>	<i>Number of students</i>
V. Ambrožič: Modern Control of AC Drives, Fakulteta za elektrotehniko, Ljubljana, 1996. (in Slovenian)	1	60
W. Leonhard: Control of Electrical Drives, Springer Verlag, 1996.	2	60
B. K. Bose: Modern Power Electronics and AC Drives, Prentice Hall, 2002.	5	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 time systems and Z – transform. Capability to analyze digital control systems. Capability to solve tasks concerning design of digital control systems

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 discrete 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 controller synthesis. Using of computer simulation methods for discrete system analysis and controller parameter identification using the root locus method. 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 controller synthesis using feedback state space variables. Description and usage of estimators in control of discrete systems.

1.4. Course content

Basic terms and definitions, Discrete systems, Mathematical descriptions, Z-transformation, Transfer function, Stability, Precision, Step response, Digital control, State space in Z-domain, Digital control in state space, Controllability of digital systems, Observability of control systems, State estimators.

1.5. Teaching methods

- | | |
|--------------------------------------------------|-----------------------------------------------------------|
| <input checked="" type="checkbox"/> lectures | <input checked="" type="checkbox"/> individual assignment |
| <input type="checkbox"/> seminars and workshops | <input type="checkbox"/> multimedia and network |
| <input checked="" type="checkbox"/> exercises | <input type="checkbox"/> laboratories |
| <input type="checkbox"/> long distance education | <input type="checkbox"/> mentorship |
| <input type="checkbox"/> fieldwork | <input type="checkbox"/> other |

1.6. Comments

1.7. Student's obligations

Course attendance, activities in class, attending laboratory exercises and writing reports, sustained knowledge checks (three 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. Assessment and evaluation of student's work during classes and on final exam

Course attendance, activities in class, attending laboratory exercises and writing reports, sustained knowledge checks (three 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

<i>Title</i>	<i>Number of copies</i>	<i>Number of students</i>
Matika, D.: Digital control systems, Textbook, TF Rijeka, 2007. (in Croatian)	3	35
Vukić, Z. and Kuljača, Lj.: Automatic Control – analysis of linear systems. Zagreb; Kigen, d.o.o., 2004. (in Croatian)	3	35
Nise, N.: Control System Engineering. New York; John Wiley and Sons, 2000.	0	35

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

- | | |
|--------------------------------------------------|------------------------------------------------------------|
| <input checked="" type="checkbox"/> lectures | <input checked="" type="checkbox"/> individual assignment |
| <input type="checkbox"/> seminars and workshops | <input checked="" type="checkbox"/> multimedia and network |
| <input type="checkbox"/> exercises | <input checked="" type="checkbox"/> laboratories |
| <input type="checkbox"/> long distance education | <input type="checkbox"/> mentorship |
| <input type="checkbox"/> fieldwork | <input type="checkbox"/> 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. Assessment and evaluation of student's work during classes and on 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.		

<i>1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences</i>		
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	2.	
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

Understand both time and frequency analysis and processing methods of discrete-time signals and systems. Understand and apply 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 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. Define Discrete Fourier Transform (DFT) and its properties. Use DFT in signal spectral analysis and processing. Use 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 (A/D and D/A signal conversion). Discrete-Time Fourier Series and 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

- | | |
|--------------------------------------------------|-----------------------------------------------------------|
| <input checked="" type="checkbox"/> lectures | <input checked="" type="checkbox"/> individual assignment |
| <input type="checkbox"/> seminars and workshops | <input type="checkbox"/> multimedia and network |
| <input checked="" type="checkbox"/> exercises | <input type="checkbox"/> laboratories |
| <input type="checkbox"/> long distance education | <input type="checkbox"/> mentorship |
| <input type="checkbox"/> fieldwork | <input type="checkbox"/> 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	0.75	Oral exam		Essay		Research	
Project	0.75	Sustained knowledge check	1.5	Report		Practice	
Portfolio							

1.9. Assessment and evaluation of student's work during classes and on final exam

Written tests, project report, final 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)

J. G. Proakis and D. G. Manolakis: Digital Signal Processing, 4/E, Prentice Hall, 2007.
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

<i>Title</i>	<i>Number of copies</i>	<i>Number of students</i>
B. P. Lathi and R. A. Green: Essentials of Digital Signal Processing, Cambridge University Press, 2014.	0	30
J. G. Proakis and D. G. Manolokis: Digital Signal Processing, 4/E, Prentice Hall, 2007.	1	30
R. J. Schilling and S. L. Harris: Fundamentals of Digital Signal Processing Using MATLAB, Thomson, 2005.	1	30
<i>1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences</i>		
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

- | | |
|--------------------------------------------------|-----------------------------------------------------------|
| <input checked="" type="checkbox"/> lectures | <input checked="" type="checkbox"/> individual assignment |
| <input type="checkbox"/> seminars and workshops | <input type="checkbox"/> multimedia and network |
| <input checked="" type="checkbox"/> exercises | <input type="checkbox"/> laboratories |
| <input type="checkbox"/> long distance education | <input type="checkbox"/> mentorship |
| <input checked="" type="checkbox"/> fieldwork | <input type="checkbox"/> 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. Assessment and evaluation of student's work during classes and on 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 McGraw 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

<i>Title</i>	<i>Number of copies</i>	<i>Number of students</i>
Prelec, Z.: Energy Engineering in Process Industry, Školska knjiga Zagreb, 1984. (in Croatian)	5	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	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)	30+30+0

3. 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

Types of power plants. The choice of parameters and characteristics of primary equipment in power plants (HPP, TPP, GPP, CHP, NPP) with respect to the requirements of the power system (GRID CODE). Non-stationary operation of hydropower plants. Technical monitoring of power plants. Island operation of power plants. Power plant capabilities for participating in (f-P) and (U-Q) regulation. Thermal power plant operation on it's own consumption.

1.5. Teaching methods

- | | |
|------------------------------------------------------------|--------------------------------------------------|
| <input checked="" type="checkbox"/> lectures | <input type="checkbox"/> individual assignment |
| <input checked="" type="checkbox"/> seminars and workshops | <input type="checkbox"/> multimedia and network |
| <input checked="" type="checkbox"/> exercises | <input checked="" type="checkbox"/> laboratories |
| <input type="checkbox"/> long distance education | <input type="checkbox"/> mentorship |
| <input checked="" type="checkbox"/> fieldwork | <input type="checkbox"/> 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							

1.9. Assessment and evaluation of student's work during classes and on 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)
 Požar, H.: Basics of power engineering 1, Školska knjiga, Zagreb, 1992. (in Croatian)
 Požar, H.: Basics of power engineering 2, Školska knjiga, Zagreb, 1992. (in Croatian)
 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

<i>Title</i>	<i>Number of copies</i>	<i>Number of students</i>
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

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

- | | |
|--------------------------------------------------|-----------------------------------------------------------|
| <input checked="" type="checkbox"/> lectures | <input checked="" type="checkbox"/> individual assignment |
| <input type="checkbox"/> seminars and workshops | <input type="checkbox"/> multimedia and network |
| <input checked="" type="checkbox"/> exercises | <input checked="" type="checkbox"/> laboratories |
| <input type="checkbox"/> long distance education | <input type="checkbox"/> mentorship |
| <input type="checkbox"/> fieldwork | <input type="checkbox"/> 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. Assessment and evaluation of student's work during classes and on 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

<i>Title</i>	<i>Number of copies</i>	<i>Number of students</i>
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.

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.

1.5. Teaching methods

- | | |
|------------------------------------------------------------|--------------------------------------------------|
| <input checked="" type="checkbox"/> lectures | <input type="checkbox"/> individual assignment |
| <input checked="" type="checkbox"/> seminars and workshops | <input type="checkbox"/> multimedia and network |
| <input checked="" type="checkbox"/> exercises | <input checked="" type="checkbox"/> laboratories |
| <input type="checkbox"/> long distance education | <input type="checkbox"/> mentorship |
| <input checked="" type="checkbox"/> fieldwork | <input type="checkbox"/> 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. Assessment and evaluation of student's work during classes and on 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

<i>Title</i>	<i>Number of copies</i>	<i>Number of students</i>
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	<input checked="" type="checkbox"/> lectures	<input checked="" type="checkbox"/> individual assignment
	<input type="checkbox"/> seminars and workshops	<input type="checkbox"/> multimedia and network
	<input checked="" type="checkbox"/> exercises	<input checked="" type="checkbox"/> laboratories
	<input type="checkbox"/> long distance education	<input type="checkbox"/> mentorship
	<input type="checkbox"/> fieldwork	<input type="checkbox"/> 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. Assessment and evaluation of student's work during classes and on 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)

Chao, H.-P., Huntington, H.G.: Designing competitive electricity markets, Kluweer Academic Publisher, SF, 2001.

Kundur, D.P.: Power System Stability and Control, McGraw-Hill, Inc., New York, USA, 1994.

Anderson, P.M., Fouad, A.A.: Power System Control and Stability (Revised printing), IEEE Press, New York, 1994.

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

<i>Title</i>	<i>Number of copies</i>	<i>Number of students</i>
Udovičić, B.: Electric power system, Kigen, Zagreb, 2005. (in Croatian)	3	32

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 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

- | | |
|--------------------------------------------------|-----------------------------------------------------------|
| <input checked="" type="checkbox"/> lectures | <input checked="" type="checkbox"/> individual assignment |
| <input type="checkbox"/> seminars and workshops | <input type="checkbox"/> multimedia and network |
| <input checked="" type="checkbox"/> exercises | <input type="checkbox"/> laboratories |
| <input type="checkbox"/> long distance education | <input type="checkbox"/> mentorship |
| <input type="checkbox"/> fieldwork | <input type="checkbox"/> 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. Assessment and evaluation of student's work during classes and on 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 electric 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

<i>Title</i>	<i>Number of copies</i>	<i>Number of students</i>
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 electric 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	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. 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.

1.5. Teaching methods

- | | |
|--------------------------------------------------|-----------------------------------------------------------|
| <input checked="" type="checkbox"/> lectures | <input checked="" type="checkbox"/> individual assignment |
| <input type="checkbox"/> seminars and workshops | <input type="checkbox"/> multimedia and network |
| <input checked="" type="checkbox"/> exercises | <input checked="" type="checkbox"/> laboratories |
| <input type="checkbox"/> long distance education | <input type="checkbox"/> mentorship |
| <input type="checkbox"/> fieldwork | <input type="checkbox"/> 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	1	Report		Practice	
Portfolio		Homework					

1.9. Assessment and evaluation of student's work during classes and on 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

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

<i>Title</i>	<i>Number of copies</i>	<i>Number of students</i>
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	

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

Knowledge about industrial robots and modelling of robot kinematics and dynamics. Ability to plan robot motion and execute planned trajectories. Application of different robot control methods. Training students to simulate individually in Mathematica and Matlab. Developing skills of individual and group work and results presentation.

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

- | | |
|--------------------------------------------------|-----------------------------------------------------------|
| <input checked="" type="checkbox"/> lectures | <input checked="" type="checkbox"/> individual assignment |
| <input type="checkbox"/> seminars and workshops | <input type="checkbox"/> multimedia and network |
| <input checked="" type="checkbox"/> exercises | <input type="checkbox"/> laboratories |
| <input type="checkbox"/> long distance education | <input type="checkbox"/> mentorship |
| <input type="checkbox"/> fieldwork | <input type="checkbox"/> 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	2	Report		Practice	
Portfolio		Simulation exercises	1				

1.9. Assessment and evaluation of student's work during classes and on final exam

Oral explanation of simulation exercises or project, continuous knowledge testing (two partial exams), written or oral final exam.

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

Z. Kovačić, S. Bogdan, V. Krajčić: Fundamentals of Robotics, Graphis, Zagreb, 2002. (in Croatian)

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

T.R. Kurfess: Robotics and Automation Handbook, CRC Press, 2005.

F.L. Lewis, D.M. Dawson, C.T. Abdallah: Robot Manipulator Control: Theory and Practice, Marcel Dekker Inc., New York, 2004.

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

<i>Title</i>	<i>Number of copies</i>	<i>Number of students</i>
Z. Kovačić, S. Bogdan, V. Krajčić: Fundamentals of Robotics, Graphis, Zagreb, 2002. (in Croatian)	3	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	Fundamentals of Statistical Signal Processing	
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)	45+15+0

4. 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

Passed course Numerical and Stochastic Mathematics; attended course Digital Signal Processing.

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

- | | |
|--------------------------------------------------|-----------------------------------------------------------|
| <input checked="" type="checkbox"/> lectures | <input checked="" type="checkbox"/> individual assignment |
| <input type="checkbox"/> seminars and workshops | <input type="checkbox"/> multimedia and network |
| <input checked="" type="checkbox"/> exercises | <input type="checkbox"/> laboratories |
| <input type="checkbox"/> long distance education | <input type="checkbox"/> mentorship |
| <input type="checkbox"/> fieldwork | <input type="checkbox"/> 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		Oral exam	0.75	Essay		Research	
Project	0.75	Sustained knowledge check	1.5	Report		Practice	
Portfolio							

1.9. Assessment and evaluation of student's work during classes and on final exam

Written tests, project report, final oral exam.

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.
 S. Engelberg: *Random Signals and Noise: A Mathematical Introduction*, CRC Press, 2007.
 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.
 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

<i>Title</i>	<i>Number of copies</i>	<i>Number of students</i>
S. M. Kay: <i>Intuitive Probability and Random Processes using MATLAB</i> , Springer, 2006.	0	20
M. Barkat: <i>Signal Detection and Estimation</i> , Artech House, 2005.	1	20
S. Engelberg: <i>Random Signals and Noise: A Mathematical Introduction</i> , CRC Press, 2007.	1	20
D. G. Manolakis, V. K. Ingle, and S. M. Kogon: <i>Statistical and Adaptive Signal Processing: Spectral Estimation, Signal Modeling, Adaptive Filtering and Array Processing</i> , Artech House, 2005.	1	20
W. A. Woyczynski: <i>A First Course in Statistics for Signal Analysis</i> , Birkhaeuser, 2006.	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	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

- | | |
|--------------------------------------------------|-----------------------------------------------------------|
| <input type="checkbox"/> lectures | <input checked="" type="checkbox"/> individual assignment |
| <input type="checkbox"/> seminars and workshops | <input type="checkbox"/> multimedia and network |
| <input type="checkbox"/> exercises | <input type="checkbox"/> laboratories |
| <input type="checkbox"/> long distance education | <input checked="" type="checkbox"/> mentorship |
| <input type="checkbox"/> fieldwork | <input type="checkbox"/> 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. Assessment and evaluation of student's work during classes and on final exam

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

<i>Title</i>	<i>Number of copies</i>	<i>Number of students</i>

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	2.	
ECTS credits and teaching	ECTS student 's workload coefficient	5
	Number of hours (L+E+S)	30+30+0

5. COURSE DESCRIPTION

1.14. 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.

1.15. Course enrolment requirements

None.

1.16. Expected course learning outcomes

After passing the course, students will be able to do the following:

1. Appoint and differentiate the elements of the power system used for the transmission of electricity on high voltage
2. Define and describe the production and measurement of high voltage
3. Group and give examples of insulation on high voltage
4. Describe the different processes that lead to breakthrough HV insulation
5. Define insulation coordination and specify nominal and test voltages for individual voltage levels
6. Identify and classify the types of surges occurring in the power system
7. Describe the formation and propagation of traveling waves

1.17. 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. Paschens 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.

1.18. Teaching methods

- lectures
 seminars and workshops
 exercises
 long distance education
 fieldwork

- individual assignment
 multimedia and network
 laboratories
 mentorship
 other

1.19. Comments

1.20. Student's obligations

Class attendance, laboratory practice, written exam.

1.21. 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							

1.22. Assessment and evaluation of student's work during classes and on final exam

Attending lectures, auditory teaching, laboratory teaching, tests, written exam.

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

High-Voltage Engineering: Fundamentals; E. Kuffel, W.S. Zaengl, J. Kuffel; Butterworth-Heinemann; 2001; ISBN: 0750636343

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

High- Voltage Engineering; M. S. Naidu, V. Kamaraju; Mc Graww-Hill; 2000; ISBN: 0074622862

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

<i>Title</i>	<i>Number of copies</i>	<i>Number of students</i>
High-Voltage Engineering: Fundamentals; E. Kuffel, W.S. Zaengl, J. Kuffel; Butterworth-Heinemann; 2001; ISBN: 0750636343	0	40

1.26. 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

- | | |
|--------------------------------------------------|-----------------------------------------------------------|
| <input checked="" type="checkbox"/> lectures | <input checked="" type="checkbox"/> individual assignment |
| <input type="checkbox"/> seminars and workshops | <input type="checkbox"/> multimedia and network |
| <input checked="" type="checkbox"/> exercises | <input type="checkbox"/> laboratories |
| <input type="checkbox"/> long distance education | <input type="checkbox"/> mentorship |
| <input type="checkbox"/> fieldwork | <input type="checkbox"/> 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. Assessment and evaluation of student's work during classes and on final exam

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

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
<i>1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences</i>		
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

- | | |
|--------------------------------------------------|-----------------------------------------------------------|
| <input checked="" type="checkbox"/> lectures | <input checked="" type="checkbox"/> individual assignment |
| <input type="checkbox"/> seminars and workshops | <input type="checkbox"/> multimedia and network |
| <input checked="" type="checkbox"/> exercises | <input checked="" type="checkbox"/> laboratories |
| <input type="checkbox"/> long distance education | <input type="checkbox"/> mentorship |
| <input type="checkbox"/> fieldwork | <input type="checkbox"/> other |

1.6. Comments

-

1.7. Student's obligations

Course attendance, working reports

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	Report		Practice	
Portfolio		Laboratory exercises	0.5				

1.9. Assessment and evaluation of student's work during classes and on 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

<i>Title</i>	<i>Number of copies</i>	<i>Number of students</i>
		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	Numerical Analysis in Electromagnetism	
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+15+0

1. COURSE DESCRIPTION

1.1. Course objectives

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

Apply modeling and simulation techniques related to low-frequency electromagnetic fields. Explain the basics of finite-difference method, finite element method and the moments method. Explain the advantages and limitations of different methods. Compare the technique of sparse and compact matrix. Describe the elimination methods and iterative methods in solving algebraic equations. Explain the component of CAD systems in electromagnetism. Assess the complexity of CAD system for electromagnetic design. Assess the role of CAD in engineering design. Apply a commercial FEM programs . Apply CAD programs to create a virtual prototype of electromagnetic devices.

1.4. Course content

Theory of electromagnetic. 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	<input checked="" type="checkbox"/> lectures	<input type="checkbox"/> individual assignment
	<input type="checkbox"/> seminars and workshops	<input type="checkbox"/> multimedia and network
	<input type="checkbox"/> exercises	<input checked="" type="checkbox"/> laboratories
	<input type="checkbox"/> long distance education	<input type="checkbox"/> mentorship
	<input type="checkbox"/> fieldwork	<input type="checkbox"/> other

1.6. Comments

1.7. Student's obligations

Lectures, activity in laboratory, studying.

1.8. Evaluation of student's work

Course attendance	1.5	Activity/Participation	1	Seminar paper		Experimental work	
Written exam	1.5	Oral exam		Essay		Research	
Project		Continuous knowledge testing	1	Report		Practice	
Portfolio							

1.9. Assessment and evaluation of student's work during classes and on final exam

Course attendance, activity in laboratory, continuous knowledge testing, written exam.

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

L. Šušnjić: Numerical analysis of electromagnetism, e-learning material in Croatian
 Z. Haznadar, Ž. Štih,,: Elektromagnetism I, II, Školska knjiga , Zagreb, 1997.
 FLUX 2D, "CAD package for electromagnetic and thermal analysis using finite elements", CEDRAT

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

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

<i>Title</i>	<i>Number of copies</i>	<i>Number of students</i>
Z. Haznadar, Ž. Štih: Elektromagnetism I, II, Školska knjiga, Zagreb, 1997	1	42
FLUX 2D, "CAD package for electromagnetic and thermal analysis using finite elements", CEDRAT	42	42

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)	30+30+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. Compare computational methods applicable to the same type of problem. Apply existing software to simpler problems. Write simple computer programs for particular computational methods by following instructions. Evaluate results of computational methods.

Define and interpret correctly: random experiments, events, basic operations with events, probabilities of events. Recognize events in practical experiments and compute their probabilities. 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.
 Numerical methods for solving linear systems: direct and iterative methods.
 Curve fitting: interpolation polynomial and interpolation splines, regression.
 Numerical integration and differentiation.
 Numerical methods for solving ordinary differential equations.
 Basics of probability theory: events, probability and probability space. Bayes theorem.
 Random variables and standard distributions. Random vectors.
 Stochastic processes. Markov chains.

1.5. Teaching methods

- | | |
|--------------------------------------------------|--------------------------------------------------|
| <input checked="" type="checkbox"/> lectures | <input type="checkbox"/> individual assignment |
| <input type="checkbox"/> seminars and workshops | <input type="checkbox"/> multimedia and network |
| <input checked="" type="checkbox"/> exercises | <input checked="" type="checkbox"/> laboratories |
| <input type="checkbox"/> long distance education | <input type="checkbox"/> mentorship |
| <input type="checkbox"/> fieldwork | <input type="checkbox"/> other |

1.6. Comments

1.7. Student's obligations

Class attendance, activity, mid-term exams, tests, tests on computer.

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. Assessment and evaluation of student's work during classes and on 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, McGrawHill 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)

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

<i>Title</i>	<i>Number of copies</i>	<i>Number of students</i>
Chapra S. C., Channale R. P.: Numerical methods for engineers, McGrawHill Inc., 1988	15	100
Črnjarić-Žic N., Internal lecture notes with solved problems from Engineering statistics, Rijeka 2010. (in Croatian)	100	100
Elezović, N., Discrete probability, Random variables, Statistics and processes, Biblioteka Bolonja, Element, Zagreb 2007	3	100

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

Students are introduced to physical process of semiconductor light absorption and its mathematical models. Knowledge of different technological ways of using photoelectric conversion in photonic components and sensors (light sources and detectors) and its application is obtained. In experimental work within laboratory exercises the goal is to design and build an image sensor using discrete electronic elements, based on its analysis and electrical characterization, as well as research its possible application. Solar cell characterisation and model parameter calculation in order to implement it as an energy source is another course objective.

1.2. Course enrolment requirements

None.

1.3. Expected course learning outcomes

Ability to describe semiconductor characteristics: generation-recombination process, optical generations, charge carrier concentrations, energy diagrams, heterojunctions and nanostructures. Monocrystalline silicon pn junction and heterojunction characteristics analysis. Light sources description. Photoresistors, photodiodes, phototransistors and solar cells analysis. Application of LED light sources and photodiodes in realisation of light detector in active pixel sensors and CCDs. Implementation of solar cells as energy sources. Differentiating between photodiode and solar cell parameters. Description of CCD and APS.

1.4. Course content

Semiconductors physical characteristics: crystal structure, energy diagrams, free charge carrier concentrations in thermal equilibrium, optical and thermal features, generation and recombination in semiconductors, semiconductor equations. Semiconductor components: pn junctions, heterojunctions. Photonic components and sensors. Light sources. Radiative transitions, LED, lasers, detectors, photosensors, photodiodes, avalanche diodes, phototransistors, charge-coupled devices (CCD), CMOS sensors, active pixel sensors (APS), solar cells.

1.5. Teaching methods

- | | |
|-------------------------------------------------------------|------------------------------------------------------------|
| <input checked="" type="checkbox"/> lectures | <input checked="" type="checkbox"/> individual assignment |
| <input type="checkbox"/> seminars and workshops | <input checked="" type="checkbox"/> multimedia and network |
| <input checked="" type="checkbox"/> exercises | <input checked="" type="checkbox"/> laboratories |
| <input checked="" type="checkbox"/> long distance education | <input type="checkbox"/> mentorship |
| <input type="checkbox"/> fieldwork | <input type="checkbox"/> other |

1.6. Comments

1.7. Student's obligations

Course attendance, activity, web test and quiz, homework, studying.

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. Assessment and evaluation of student's work during classes and on 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)

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

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

Stephen J. Fonash, Solar Cell Device Physics, Burlington, Kidlington, Oxford, Elsevier, 2010.

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

<i>Title</i>	<i>Number of copies</i>	<i>Number of students</i>
S.M.Sze, K.K. Ng, Physics of Semiconductor Devices, 3rd 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	50
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
Stephen J. Fonash, Solar Cell Device Physics, Burlington, Kidlington, Oxford, Elsevier, 2010.	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

6. COURSE DESCRIPTION

1.14. Course objectives

Adoption of the theoretical knowledge and skills for solving technical problems in the field of design, operation and maintenance of power plants.

1.15. Course enrolment requirements

None.

1.16. 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.

1.17. 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. Hydro-electric power plant.

1.18. Teaching methods	<input checked="" type="checkbox"/> lectures	<input type="checkbox"/> individual assignment
	<input type="checkbox"/> seminars and workshops	<input type="checkbox"/> multimedia and network
	<input checked="" type="checkbox"/> exercises	<input type="checkbox"/> laboratories
	<input type="checkbox"/> long distance education	<input type="checkbox"/> mentorship
	<input checked="" type="checkbox"/> fieldwork	<input type="checkbox"/> other

1.19. Comments

1.20. Student's obligations

Course attendance, activity, studying

1.21. 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							

1.22. Assessment and evaluation of student's work during classes and on final exam

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

1.23. 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)

1.24. 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,
 El-Vakil, M.: Power plant technology, Mc Graw Hill Book Company, 1988.

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

<i>Title</i>	<i>Number of copies</i>	<i>Number of students</i>
Prelec, Z.: Energetics in process industry, Školska knjiga, Zagreb, 1994. (in Croatian)	10	40

1.26. 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

- | | |
|--------------------------------------------------|-------------------------------------------------|
| <input type="checkbox"/> lectures | <input type="checkbox"/> individual assignment |
| <input type="checkbox"/> seminars and workshops | <input type="checkbox"/> multimedia and network |
| <input type="checkbox"/> exercises | <input type="checkbox"/> laboratories |
| <input type="checkbox"/> long distance education | <input type="checkbox"/> mentorship |
| <input checked="" type="checkbox"/> fieldwork | <input type="checkbox"/> 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. Assessment and evaluation of student's work during classes and on final exam

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

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

<i>1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences</i>		
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

- | | |
|--------------------------------------------------|-----------------------------------------------------------|
| <input type="checkbox"/> lectures | <input checked="" type="checkbox"/> individual assignment |
| <input type="checkbox"/> seminars and workshops | <input type="checkbox"/> multimedia and network |
| <input type="checkbox"/> exercises | <input type="checkbox"/> laboratories |
| <input type="checkbox"/> long distance education | <input checked="" type="checkbox"/> mentorship |
| <input type="checkbox"/> fieldwork | <input type="checkbox"/> 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. Assessment and evaluation of student's work during classes and on 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.

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

<i>1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences</i>		
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

- | | |
|--------------------------------------------------|-----------------------------------------------------------|
| <input type="checkbox"/> lectures | <input checked="" type="checkbox"/> individual assignment |
| <input type="checkbox"/> seminars and workshops | <input type="checkbox"/> multimedia and network |
| <input type="checkbox"/> exercises | <input type="checkbox"/> laboratories |
| <input type="checkbox"/> long distance education | <input checked="" type="checkbox"/> mentorship |
| <input type="checkbox"/> fieldwork | <input type="checkbox"/> 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. Assessment and evaluation of student's work during classes and on 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.

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

<i>1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences</i>		
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 protection 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

- | | |
|------------------------------------------------------------|--------------------------------------------------|
| <input checked="" type="checkbox"/> lectures | <input type="checkbox"/> individual assignment |
| <input checked="" type="checkbox"/> seminars and workshops | <input type="checkbox"/> multimedia and network |
| <input checked="" type="checkbox"/> exercises | <input checked="" type="checkbox"/> laboratories |
| <input type="checkbox"/> long distance education | <input type="checkbox"/> mentorship |
| <input checked="" type="checkbox"/> fieldwork | <input type="checkbox"/> 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	
Written exam	0.5	Oral exam		Essay		Research	
Project		Sustained knowledge check	1.5	Report		Practice	
Portfolio							

1.9. Assessment and evaluation of student's work during classes and on 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

<i>Title</i>	<i>Number of copies</i>	<i>Number of students</i>
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	Radiocommunications	
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 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. Describe and apply antenna parameters. 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, dynamic range 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 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 L-network. Impedance transformation by stub. Quarter-wave impedance transformer. Binomial impedance transformer. Fundamental antenna parameters. Communication channel and effects on wave propagation. RF link budget. An overview of propagation models for field prediction. Noise in the system. Intermodulation distortion. Dynamic range. Image frequency.

1.5. Teaching methods

- | | |
|--------------------------------------------------|-------------------------------------------------|
| <input checked="" type="checkbox"/> lectures | <input type="checkbox"/> individual assignment |
| <input type="checkbox"/> seminars and workshops | <input type="checkbox"/> multimedia and network |
| <input checked="" type="checkbox"/> exercises | <input type="checkbox"/> laboratories |
| <input type="checkbox"/> long distance education | <input type="checkbox"/> mentorship |
| <input type="checkbox"/> fieldwork | <input type="checkbox"/> 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. Assessment and evaluation of student's work during classes and on 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, 3rd ed., Wiley, 2005.

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, 3rd ed, Wiley-Interscience, 2005.

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

<i>Title</i>	<i>Number of copies</i>	<i>Number of students</i>
D. M. Pozar, Microwave Engineering, 3rd ed., Wiley, 2005.	-	42
J. D. Parsons, The Mobile Radio Propagation Channel, 2nd ed, Wiley, 2000.	-	42
C. A. Balanis, Antenna Theory: Analysis and Design, 3rd ed, Wiley-Interscience, 2005.	-	42

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	Theoretical Electrical 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)	30+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.

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 electromagnetism in computer engineering. Identify the different equations describing electromagnetic processes. Derive the equations describing electromagnetic phenomena. Formulate the basic laws of electromagnetism. Solve differential equations using separation of variables . Analyze simple electromagnetic system. Apply electromagnetic theory in simple practical situations . Explain the meaning and consequences of quantum field theory. Interpret solutions

1.4. Course content

Vector analysis. Coulomb's law and electric field strength. Gauss' law and divergence. Energy and potential. Conductors, insulators and capacity. Experimental graphical methods. Poisson's and Laplace equation. The static magnetic field, magnetic forces, materials and inductance. The time variable magnetic field and Maxwell's equations, homogeneous plane wave. Quasi-static model.

1.5. Teaching methods

- | | |
|--------------------------------------------------|-------------------------------------------------|
| <input checked="" type="checkbox"/> lectures | <input type="checkbox"/> individual assignment |
| <input type="checkbox"/> seminars and workshops | <input type="checkbox"/> multimedia and network |
| <input checked="" type="checkbox"/> exercises | <input type="checkbox"/> laboratories |
| <input type="checkbox"/> long distance education | <input type="checkbox"/> mentorship |
| <input type="checkbox"/> fieldwork | <input type="checkbox"/> other |

1.6. Comments

1.7. Student's obligations

Lectures, activity, 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		Continuous knowledge testing	2	Report		Practice	
Portfolio							

1.9. Assessment and evaluation of student's work during classes and on final exam

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

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

L. Šušnjić: Teoretical Electrical Engineeringa,e-learning material
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

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

<i>Title</i>	<i>Number of copies</i>	<i>Number of students</i>
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	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. Symmetrical components and the parameters for non-symmetrical operational states. The theory 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 theory 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

- | | |
|--------------------------------------------------|-----------------------------------------------------------|
| <input checked="" type="checkbox"/> lectures | <input checked="" type="checkbox"/> individual assignment |
| <input type="checkbox"/> seminars and workshops | <input type="checkbox"/> multimedia and network |
| <input checked="" type="checkbox"/> exercises | <input type="checkbox"/> laboratories |
| <input type="checkbox"/> long distance education | <input type="checkbox"/> mentorship |
| <input type="checkbox"/> fieldwork | <input type="checkbox"/> 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. Assessment and evaluation of student's work during classes and on 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.
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.
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

<i>Title</i>	<i>Number of copies</i>	<i>Number of students</i>
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

7. COURSE DESCRIPTION

Course objectives

Understanding the concept of urban energy systems. Acquiring theoretical fundamentals as well as practical knowledge in solving problems regarding automatisisation, energy system and process analysis.

1.1. Course enrolment requirements

None.

1.2. Expected course learning outcomes

Describe the role and structure of automatisisation 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.

1.3. Course content

Energy system overview. Introduction to process automatisisation. Reasons, principles and advantages of automatisisation. Levels of process control. Automatisisation 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.

1.4. Teaching methods

- | | |
|--------------------------------------------------|-----------------------------------------------------------|
| <input checked="" type="checkbox"/> lectures | <input checked="" type="checkbox"/> individual assignment |
| <input type="checkbox"/> seminars and workshops | <input type="checkbox"/> multimedia and network |
| <input checked="" type="checkbox"/> exercises | <input type="checkbox"/> laboratories |
| <input type="checkbox"/> long distance education | <input type="checkbox"/> mentorship |
| <input checked="" type="checkbox"/> fieldwork | <input type="checkbox"/> other |

1.5. Comments

1.6. Student's obligations

Course attendance, project, studying.

1.7. 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							

1.8. Assessment and evaluation of student's work during classes and on final exam

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

1.9. 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.

1.10. 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.

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

<i>Title</i>	<i>Number of copies</i>	<i>Number of students</i>
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

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

Through the Institution's quality assurance system.