University of Rijeka
FACULTY OF ENGINEERING

Doctoral Study in the area of Technical Sciences, in the field of Electrical Engineering

Study programme

Rijeka, April 2020

University of Rijeka
FACULTY OF ENGINEERING

Basic information	
Title of study programme	Doctoral Study in the area of Technical Sciences, in the field of Electrical Engineering
Study programme coordinator	University of Rijeka – Faculty of Engineering
Study programme implementor	University of Rijeka – Faculty of Engineering
Type of study programme	Postgraduate University Doctoral Study
Level of study programme	Level 8.2
Academic/professional degree awarded upon completion of study	Doctor of Science
Title and code of the qualification standard acquired upon the finishing od the study (if the programme is enrolled in the CROQF Register)	-

1. INTRODUCTION

1.1. Study goals and learning outcomes

The proposed postgraduate study programme in the area of Technical Sciences, in the field of Electrical Engineering aims to provide Masters of Electrical Engineering graduated from the Faculty of Engineering, and other related institutions in Croatia and abroad, the opportunity to continue the education and their further scientific training.

Current aims of Croatian society are transformation into a knowledge society and European and global integration. Croatia needs to develop into a modern society and the economy of experts, and a country of wise international political partner of large systems and mature democracies. The weakening of the productive sector in the economy and the decline in the number of students enrolled into programmes in technical and natural sciences must be stopped in the same way that was done in the countries which have successfully completed the aforementioned transformation. The study programme will educate researchers who will be able to contribute to the accomplishment of the aforementioned aims. Some researchers who remain in the higher education and scientific research system will educate new generations of engineers and scientists, but they will also generate new research results, enable the transfer of knowledge and, through their research and contacts with foreign researchers, help Croatia with European and global integration and growth. There is even a greater need of our economy for creative and enterprising young researchers who will help the economy grow. The key element in the future of Croatia are awakened creators, expert engineers and capable entrepreneurs whose technological creations can be sold all over the world.

Since 1999 until today, the education of Graduate Electrical Engineers and Masters of Electrical Engineering at the Faculty of Engineering of the University of Rijeka has been satisfying the needs for highly educated professionals in the field of Electrical Engineering in the Primorsko-Goranska County and in the neighbouring counties. However, in the same period there has been a growing need for doctors of science in the same area. The initiation of this study will provide larger economic entities (HEP, INA, shipyards, Port of Rijeka) additional training of existing employees, but also employment opportunities for new Doctors of Science. It is also expected that graduated students from the suggested study will further foster innovation and development of new technologies in a number of small and medium enterprises operating in the fields of industrial and naval electronics, embedded systems, information and communication technologies. The Faculty of Engineering and other constituents of the University of Rijeka have been lacking new researchers at the doctoral level in the field of Electrical Engineering for many years, and it is expected that a part of the students of the proposed study programme will continue to work at the University of Rijeka.

Existing scientific and professional projects and sustained cooperation with industry and entrepreneurship are the bases and the assumption for the continuity and further development of collaborative research that will be additionally fostered by the proposed study programme. Professionals from the industry are involved in the design and drafting of the proposed study programme, and their cooperation in implementing the study is also foreseen. Cooperation with larger industries (such as HEP, Uljanik shipyard) is expected in the first place, but collaborations with small and medium enterprises are also expected. In particular, small and medium enterprises that were created using the knowledge and results of the research conducted at the Faculty of Engineering, companies that are based on the application of the latest technical solutions, which are creating new products and employing former students of the Faculty of Engineering will be involved. Students will also have the possibility to research at the university centres such as the Science and Technology Park and the Centre for Advanced Computing and Modelling. The emphasis on multidisciplinary studies and application of innovative technologies in other areas of society will allow connection with local communities and associations that seek to improve the quality of life of the wider community. Extensive experience of doctoral studies in the field of Mechanical Engineering, Naval Architecture, Fundamental Engineering Sciences and Interdisciplinary Engineering Sciences, and the cooperation with the local community in these engineering fields will be a link to improve research activities and to broaden the impact of the proposed doctoral study.
As we are witnessing the rapid development of new technologies, methods and procedures, as well as scientific advances in the STEM field today, the directions of scientific research have crystallised, towards accomplishing new goals and which can make a significant scientific contribution within the already existing structure of study programmes. Furthermore, since the Faculty of Engineering in Rijeka has been investing significant funds in the procurement of scientific research and teaching equipment, the foundations for scientific research have been expanded. Also, the Faculty is actively supporting a large number of scientific research projects in which research recognised in international scientific circles is carried out, and in this connection the study programme follows the modern trends of research recognised. The learning outcomes of individual subjects were determined in a way that their descriptors clearly express the level of study and clearly mark the way of achieving the learning outcomes of the whole study, which are harmonised with the CROQF methodology and defined as follows:

Scientific research contribution

- Formulate a hypothesis for scientific research
- Apply a scientific method (theoretical, experimental, analytical, numeric, or similar) with the aim of confirming or rejecting the hypothesis
- Create one's own theories, methods, procedures, models, and other scientific results
- Analyse and revise existing sources and databases with the aim of collecting data needed for carrying out own research

Scientific collaboration

- Establish collaboration with other researchers from the country and abroad
- Apply and lead a national/international research project – prepare the project proposal, establish a financial plan, achieve project goals, report regularly on project work
- Independently or as a member of a research group, carry out scientific research and critically evaluate existing theories and research results

Dissemination skills

- Present to the wider public and popularise the results of own scientific research
- Publish a research paper in a major international journal
- Publish and present a research paper at an international scientific event (workshop, congress, conference)

Social responsibility

- Develop innovative solutions through creative activities with the aim of increasing the knowledge of the society
- Use scientific methods to solve complex economic and other problems
- Take ethical and social responsibility in carrying out scientific research successfully, especially taking into consideration the social relevance of research results

The achievement of such learning outcomes will further contribute to: improving postgraduate education in Croatia, increasing the comparability of postgraduate programmes with similar programs in the EU, further promoting cooperation with other universities and institutes at home and abroad, increasing the quality of research work, educating doctoral students who should be at a similar level of education as those in Western Europe and the USA, educating professionals who will further enhance education, science, the economy and other segments of our society.

1.2. Experience to date

The Faculty of Engineering of the University of Rijeka presently implements the Doctoral Study in the area of Technical Sciences, in the fields of Mechanical Engineering, Naval Architecture, Fundamental Engineering Sciences and Interdisciplinary Engineering Sciences. Studies in the field of Electrical Engineering were implemented at the Faculty of Engineering in the form of undergraduate vocational studies in 1987, and in the form of former graduate university studies in 1999. Currently, the Faculty of Engineering is implementing the studies in the field of Electrical Engineering at the undergraduate and graduate level and in accordance with the Bologna declaration, and since 2012 they have been complemented with the postgraduate level of studies. Namely, in order to further strengthen the results of the research and use the positive experience of the established studies in the fields of Mechanical Engineering, Naval Architecture, Fundamental Engineering Sciences and Interdisciplinary Engineering Sciences, the Council of the Faculty of Engineering decided to establish a postgraduate doctoral study covering the field of Electrical Engineering and thus encourage synergy of knowledge from these complementary fields of the Engineering Science. Therefore, in the 2012/2013 academic year, the Doctoral Study in the scientific field of Electrical Engineering started with its implementation. The proposed study proved to be successful, as confirmed by the results of the new self-analysis and evaluation of the Committee for the Re-accreditation of Postgraduate Study Programmes (in June 2016). However, further improvements have been made to increase the quality of studies and strengthen the learning outcomes of prospective doctoral students.

The improved study programme was approved for implementation by the decree of the Senate of the University of Rijeka in March 2020. It is aligned with the Strategy of Science Development, which was highlighted as a positive example by the Expert Committee in the Process of Re-accreditation of the Faculty of Engineering in Rijeka (August 2018). It is also aligned with the Strategy of the University of Rijeka (Strategy 2014-2020, University of Rijeka, 2014), primarily for the purpose of enhancing the University's visibility in the research context and expanding the pool of scientists and researchers in the field of Electrical Engineering. Finally, with the goal to strengthen the research of the University of Rijeka, the programme increases competitiveness and enables the monitoring of current trends. It is also expected to contribute to an increase in the number of scientific papers published in high-ranking journals indexed in the most important scientific bases, which will further contribute to the Faculty's reputation, and the University of Rijeka will be ranked better in the world rankings of universities.

2. IMPLEMENTATION OF THE STUDY PROGRAMME

Due to the valid Regulations on Doctoral Study Programmes, which are harmonised with the provisions of the University of Rijeka Study Regulations, the organisation of studies, the procedure and criteria for admission, the guidance through the programme, the execution of the programme and programme obligations, doctoral dissertation and completion of the programme, as well as the student rights and responsibilities are determined.

3. PROGRAMME DESCRIPTION

The study is conducted in the scientific field of Electrical Engineering within the scientific area of Technical Sciences. Subjects in the area of study cover the aforementioned scientific field and are organised by subject areas - modules. The modules are of advisory nature and have been formed for the purpose of a clearer overview of related subjects. The modules in the study are: Electronic Information Systems and Electric Power Systems and New Technologies.

Common courses

LIST OF MODULES/COURSES							
Year of study: 1.							
Semester: 1.							
MODULE	COURSE	COURSE INSTRUCTOR	L	E	S	ECTS	STATUS
All modules	Methodology of the scientific-research work		15	0	0	6	C
	Mathematical modeling and numerical methods		15	0	0	6	E
	Optimization methods		15	0	0	6	E
	Statistical methods and stochastic processes		15	0	0	6	E
	Freely selected course		15	0	0	6	E

Module 1: Electronic-information systems

LIST OF MODULES/COURSES							
Year of study: 1							
Semester: 1							
MODULE	COURSE	COURSE INSTRUCTOR	L	E	S	ECTS	STATUS
Electronic-information systems	Mixed signal processing		15	0	0	6	E
	Electromagnetic Modeling		15	0	0	6	E
	Photonic Devices		15	0	0	6	E
	Measurement and Analysis of Electric Power Quality		15	0	0	6	E
	Intelligent manufacturing systems		15	0	0	6	E
	Intelligent robots and manipulators		15	0	0	6	E

LIST OF MODULES/COURSES							
Year of study: 1							
Semester: 2							
MODULE	COURSE	COURSE INSTRUCTOR	L	E	S	ECTS	STATUS
Electronic-information systems	Nonstationary Signal Analysis and Processing		15	0	0	6	E
	Ambient intelligence		15	0	0	6	E
	Advanced Digital Signal Processing Methods		15	0	0	6	E
	Industrial digital control system		15	0	0	6	E
			15	0	0	6	E

Module 2: Electric power systems and new technologies

LIST OF MODULES/COURSES							
Year of study: 1							
Semester: 1							
MODULE	COURSE	COURSE INSTRUCTOR	L	E	S	ECTS	STATUS
Electric power systems and new technologies	Energy efficiency in electrical systems		15	0	0	6	E
	Modelling of Electrical Power Transmission and Distribution Systems		15	0	0	6	E
	Reliability of Technical Systems		15	0	0	6	E
	Control of Synchronous Machines		15	0	0	6	E
	Power system optimization		15	0	0	6	E

LIST OF MODULES/COURSES							
Year of study: 1							
Semester: 2							
MODULE	COURSE	COURSE INSTRUCTOR	L	E	S	ECTS	STATUS
Electric power systems and new technologies	Active Distribution Networks		15	0	0	6	E
	Intelligent Power Systems - Smart Grids		15	0	0	6	E
	Selected Chapters on Energy Components and Systems of Renewable Energy Sources		15	0	0	6	E
	The elements of energy transition		15	0	0	6	E

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COURSE DESCRIPTION		
Course instructor		
Name of the course	Active distribution networks	
Study programme	Doctoral Study in the area of Technical Sciences, in the field of Electrical Engineering	
Status of the course	elective	
Year of study	1	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	15+0+0

1.1. Course objectives

The objectives of the course are to train students for understanding active distribution network's specificities, and to apply, analyze and define appropriate methods for calculations and analysis of active distribution networks.

1.2. Course enrolment requirements

None.

1.3. Expected learning outcomes

Analyze and validate the impact of distributed generation and energy storage facilities on the electric distribution network,
Model the elements of an active distribution network,
Apply advanced methods for the calculation of active distribution networks,
Apply new type of protection for active distribution networks,
Critically asses existing schemes and design optimal schemes for connecting distributed generation and energy storage facilities.

1.4. Course content

General consideration about the integration of distributed energy sources into the distribution network. Energy circumstances in active distribution networks (voltage profile, short circuit currents, flickers, higher harmonics). Modeling elements for calculations. Network protection from faults - protection of distributed generation, protection of active distribution network. Impact of distributed generation on the power system. Smart metering devices for measurement of electricity consumption. Expected development of smart grids.

1.5. Manner of instruction	☒ lectures ☐ seminars and workshops ☐ exercises ☐ distance learning ☐ fieldwork	☒ individual assignments ☐ multimedia and network ☐ laboratories ☒ mentorship ☐ other
1.6. Comments		

1.7. Student responsibilities

Students are required to attend classes, write a seminar and a project and access the oral exam. Seminar and project to be done in consultation with the teacher.

1.8. Monitoring of student work[1]

[1] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

Class attendance	0,5	Class participation		Seminar paper	2	Experimental work	
Written exam		Oral exam	1,5	Essay		Research	
Project	2	Continuous assessment		Report		Practical work	
Portfolio							

1.9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

Assessment and evaluation of students' work will be done on the basis of the results of their seminar, project and oral exam.

1.10. Mandatory literature (at the time of submission of study programme proposal)

1. N. Jenkins; J.B. Ekanayake; G. Strbac; Distributed Generation, IET, 2010.

1.11. Optional/additional literature (at the time of submission of the study programme proposal)

1. S. Chowdhury; S.P. Chowdhury; P. Grossley; Microgrids and Active Distribution Networks, IET, 2009.

1.12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
N. Jenkins; J.B. Ekanayake; G. Strbac; Distributed Generation, IET, 2010	1	3-5

1.13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

Through the institution's quality assurance system.

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COURSE DESCRIPTION		
Course instructor		
Name of the course	**Advanced Digital Signal Processing Methods**	
Study programme	Doctoral Study in the area of Technical Sciences, in the field of Electrical Engineering	
Status of the course	elective	
Year of study	1	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	15+0+0

1.1. Course objectives

Obtaining the theoretical and practical knowledge about the advanced digital signal processing methods: wavelet transformation, time-frequency methods, blind source separation, compressive sensing and signal sparsity, local polynomial approximation, intersection of confidence intervals. Application of those methods in image, video and audio processing, feature extraction, noise suppression, and data compression.

1.2. Course enrolment requirements

None.

1.3. Expected learning outcomes

Analyse the non-stationary signals using the wavelet and time-frequency transformations;
Analyse the signals using the independent and principal component analysis;
Apply the sparsity constraint for reconstruction of the compressive sensed signals;
Apply the local polynomial approximation;
Apply the learned methods for the processing of more complex signals (image, video, audio, etc.);
Apply the learned methods for the feature extraction, noise suppression and data compression.

1.4. Course content

Orthonormal basis for signal representation. Hilbert spaces. Discrete wavelet transformation. Wavelet packets. Image compression. Time-frequency transformations.
Definition of the blind source separation. Independent and principal component analysis.
Signal sparsity. Compressive sensing. Sparse solution of underdetermined systems. Conditions for the successful signal reconstruction. Algorithms for the l0-norm and l1-norm minimization.
Local polynomial approximation (LPA). Window selection methods based on the intersection of confidence intervals method. LPA based image reconstruction.

1.5. Manner of instruction	☐ lectures ☐ seminars and workshops ☐ exercises ☐ distance learning ☐ fieldwork	☒ individual assignments ☐ multimedia and network ☐ laboratories ☒ mentorship ☐ other
1.6. Comments	---	

1.7. Student responsibilities

Students are mandatory to make a project, and write a report based on their research under guidance of the course instructor, and attend the oral exam.

1.8. Monitoring of student work[2]							
Class attendance	0,5	Class participation		Seminar paper	1	Experimental work	
Written exam		Oral exam	1	Essay		Research	3
Project	0,5	Continuous assessment		Report		Practical work	
Portfolio							

1.9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

Student assessment will be performed based on the results of the project, written report, and the oral exam.

1.10. Mandatory literature (at the time of submission of study programme proposal)

D. F. Walnut: *An Introduction to Wavelet Analysis*, Birkhauser, 2004.
A. Hyvarinen, J. Karhunen, E. Oja: *Independent Component Analysis*, John Wiley & Sons, 2004.
S. Foucart, H. Holger: *A Mathematical Introduction to Compressive Sensing*, Birkhauser, 2013.

1.11. Optional/additional literature (at the time of submission of the study programme proposal)

B. Boashash: Time Frequency Signal Analysis and Processing: A Comprehensive Reference 2nd Edition, Elsevier, 2016.
V. Katkovnik, K. Egiazarian, J. Astola: Local Approximation Techniques in Signal and Image Processing, SPIE Press, 2006.

1.12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
D. F. Walnut: *An Introduction to Wavelet Analysis*, Birkhauser, 2004.	0	
A. Hyvarinen, J. Karhunen, E. Oja: *Independent Component Analysis*, John Wiley & Sons, 2004.	0	
S. Foucart, H. Holger: *A Mathematical Introduction to Compressive Sensing*, Birkhauser, 2013.	0	

1.13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

Through the Institution's quality assurance system.

[2] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

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COURSE DESCRIPTION		
Course instructor		
Name of the course	Ambient intelligence	
Study programme	Doctoral Study in the area of Technical Sciences, in the field of Electrical Engineering	
Status of the course	elective	
Year of study	1	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	15+0+0

1.1. Course objectives

1.2. Course enrolment requirements

None.

1.3. Expected learning outcomes

Analyze the smart environments
Analyze existing ubiquitous computing literature
Analyse, propose and implement new algorithms for location based and context-aware systems
Propose hypothesis for scientific research in the field of ambient assisted living
Publish scientific paper in relevant international journal or international scientific conference
Assume ethical and social responsibility during research, taking in consideration social importance of research results.

1.4. Course content

Smart environments. Smart networked objects. Ubiquitous computing. Location based and context-aware systems. Intelligent interfaces. Ambient assisted living.

1.5. Manner of instruction		
	☒ lectures	☒ individual assignments
	☐ seminars and workshops	☐ multimedia and network
	☐ exercises	☐ laboratories
	☐ distance learning	☒ mentorship
	☐ fieldwork	☐ other

1.6. Comments

1.7. Student responsibilities

1.8. Monitoring of student work[3]

Class attendance	0,5	Class participation		Seminar paper	2	Experimental work	
Written exam		Oral exam	1,5	Essay		Research	
Project	2	Continuous assessment		Report		Practical work	

[3] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

Portfolio							

1.9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

1.10. Mandatory literature (at the time of submission of study programme proposal)

H. Nakashima; H. Aghajan; J. C. Augusto; Handbook of Ambient Intelligence and Smart Environments, Springer, 2009.

1.11. Optional/additional literature (at the time of submission of the study programme proposal)

1.12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
H. Nakashima; H. Aghajan; J. C. Augusto; Handbook of Ambient Intelligence and Smart Environments, Springer, 2009.	1	

1.13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

Through the institution's quality assurance system.

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COURSE DESCRIPTION			
Course instructor			
Name of the course	Control of synchronous machines		
Study programme	Doctoral Study in the area of Technical Sciences, in the field of Electrical Engineering		
Status of the course	elective		
Year of study	1		
ECTS credits and manner of instruction	ECTS credits	6	
	Number of class hours (L+E+S)	15+0+0	

1.1. Course objectives

Analysis of a synchronous machine operation performance in mains parallel connection and in case of operation on frequency converters.

1.2. Course enrolment requirements

None.

1.3. Expected learning outcomes

Investigate the operation of a synchronous machine operating on a power system and powered by a frequency converter. Analyze the stability of the operating point. Understand the control structure and control system for the synchronous machine.

1.4. Course content

Mathematical model of synchronous machine.
Stability of operation point of the synchronous machine connected to the power system
Control structure, types of excitation, protection
Electromechanical oscillations, oscillation stabilization, PSS types, advanced control structures
Modern control systems, microprocessors in control systems, digital control system

1.5. Manner of instruction		
	☒ lectures	☒ individual assignments
	☐ seminars and workshops	☐ multimedia and network
	☐ exercises	☐ laboratories
	☐ distance learning	☒ mentorship
	☐ fieldwork	☐ other

1.6. Comments

1.7. Student responsibilities

Students are required to attend classes (consultations) and solve a project task.

1.8. Monitoring of student work[4]

Class attendance	0.5	Class participation		Seminar paper	2	Experimental work	
Written exam		Oral exam		Essay		Research	3.5
Project		Continuous assessment		Report		Practical work	

[4] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

Portfolio							

1.9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

Assessment and evaluation of students' work will be based on the research results they achieve and the seminar paper.

1.10. Mandatory literature (at the time of submission of study programme proposal)

P.Kundur, Power System Stability and Control, McGraw-Hill, New York, 1994.
Bimal K. Bose, Modern Power Electronics and AC Drives, Prentice Hall, ISBN: 0130167436

1.11. Optional/additional literature (at the time of submission of the study programme proposal)

G. Rogers, „Power System Oscillation“, Kluwer Academic Publishers, Springer Boston 2000.
Yuri A. Kuznetsov, „Elements of Applied Bifurcation Theory“, Second Edition, Springer 1997.
P.M. Fuad, A.A. Anderson, „ Power System Control and Stability“, IEEE PRESS, New York 1994.

1.12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
P.Kundur, „Power System Stability and Controll“, McGraw-Hill, New York, 1994.	1	
Bimal K. Bose, ”Modern Power Electronics and AC Drives”, Prentice Hall, ISBN: 0130167436	1	

1.13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

Through the institution’s quality assurance system.

COURSE DESCRIPTION		
Course instructor		
Name of the course	**Electromagnetic modeling**	
Study programme	Doctoral Study in the area of Technical Sciences, in the field of Electrical Engineering	
Status of the course	elective	
Year of study	1	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	15+0+0
1.1. Course objectives		
The objectives of the course are to teach students in principles and techniques of modern computer-aided modeling in electromagnetics. Students will learn how to select and set up a proper numerical technique, build a computational model using a commercial package or by writing their own computer code, simulate and analyze the results.		
1.2. Course enrolment requirements		
None.		
1.3. Expected learning outcomes		
Course participants will learn how to: search databases to acquire necessary information and analyze prior art in preparation to conduct their own research; make their own hypothesis of scientific research; create their own- or apply an existing- scientific method to achieve new scientific results; publish the results of their own research in the form of a scientific article being presented at an international scientific conference, or published in a reputable international journal.		
1.4. Course content		
Review of electromagnetic theory. Classification of electromagnetic (EM) problems. Finite difference method. Finitedifference time-domain method. Boundary conditions. Essentials of the method of moments and finite element method. Timeline of numerical EM methods and codes. CAD modelling: modelling of geometry, description of materials, frequency set-up, relationships between the parameters, stability issues, excitation signal, set up of boundary conditions, symmetry planes, set up of source type, result monitors, analysis of results. Simulation optimization and parameter trade-offs. Essentials of the method of moments and the finite element method.		
1.5. Manner of instruction	☒ lectures ☐ seminars and workshops ☐ exercises ☒ distance learning ☐ fieldwork	☒ individual assignments ☐ multimedia and network ☐ laboratories ☒ mentorship ☐ other
1.6. Comments		
1.7. Student responsibilities		
Students are required to attend classes, do reading-, homework-, and project- assignments.		
1.8. Monitoring of student work[5]		

[5] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

Class attendance	0,5	Class participation		Seminar paper		Experimental work	
Written exam		Oral exam		Essay		Research	
Project	2,5	Continuous assessment	3	Report		Practical work	
Portfolio							

1.9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

Assessment and evaluation of students' work will be based on the success in course assignments.

1.10. Mandatory literature (at the time of submission of study programme proposal)

M. N.O. Sadiku, Numerical Techniques in Electromagnetics with MATLAB, CRC Press, 3rd ed., 2009.

1.11. Optional/additional literature (at the time of submission of the study programme proposal)

A. Taflove and S. C. Hagness, Computational Electrodynamics: The Finite-Difference Time-Domain Method, 3rd ed, Artech House, 2005.
A. Elsherbeni and Veysel Demir, The Finite-Difference Time-Domain Method for Electromagnetics with MATLAB Simulations, SciTech Publishing, Inc., 2009.

1.12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
M. N.O. Sadiku, Numerical Techniques in Electromagnetics with MATLAB, CRC Press, 3rd ed., 2009.	1	3

1.13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

Through the institution’s quality assurance system.

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COURSE DESCRIPTION		
Course instructor		
Name of the course	**Energy efficiency in electrical systems**	
Study programme	Doctoral Study in the area of Technical Sciences, in the field of Electrical Engineering	
Status of the course	elective	
Year of study	1	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	15+0+0

1.1. Course objectives

Expand students' knowledge in the field of energy efficiency in all segments of the power system. To enable students to analyse the components of the power system and apply modern technical solutions aimed rational energy usage.

1.2. Course enrolment requirements

None.

1.3. Expected learning outcomes

Classify different technologies for energy efficiency increase applicable to power system components and subsystems.
Mathematically model the components of the power system suitable for calculation of losses and effects of the application of measures for energy efficiency increase (overhead lines, power cables, transformers, loads).
Apply current standardization, up-to-date technologies and energy indicators.
Suggest advanced control and management concepts for industrial plants.
Conduct a techno-economic analysis as basis for proposing measures for power distribution system (overhead lines, power cables, transformers), buildings (management systems) and micro-grids energy efficiency increase.
Analyse the power distribution system in terms of electricity quality and energy efficiency.

1.4. Course content

Energy efficiency and relevant standardization. Power system components modelling – overhead lines, power cables and power transformers. Building management and control system. Electricity quality issues and indicators. On site generation and microgrids. Electric motors. Electric lighting. Electrical drives and power electronics. Heating, ventilation and air-conditioning systems. Reactive power compensation.

1.5. Manner of instruction		
	☒ lectures	☒ individual assignments
	☒ seminars and workshops	☐ multimedia and network
	☐ exercises	☐ laboratories
	☐ distance learning	☒ mentorship
	☐ fieldwork	☐ other

1.6. Comments

1.7. Student responsibilities

Students are required to attend classes, write a seminar and access the oral exam.

1.8. Monitoring of student work[6]							
Class attendance	0.5	Class participation		Seminar paper	2	Experimental work	
Written exam		Oral exam	1.5	Essay		Research	
Project	2	Continuous assessment		Report		Practical work	
Portfolio							

1.9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

Evaluation of students' work will be based on the results of his seminar work, project and oral exam.

1.10. Mandatory literature (at the time of submission of study programme proposal)

A. Sumper, A. Baggini, Electrical energy efficiency, Technologies and applications, Wiley, 2012.

1.11. Optional/additional literature (at the time of submission of the study programme proposal)

Garg, A., Bhoi, A.K., Sanjeevikumar, P., Kamani, Advances in Power Systems and Energy Management, Springer, 2016.
Z. Morvaj, D. Gvozdenac, Ž. Tomšić, Sustavno gospodarenje energijom i upravljanje utjecajima na okoliš u industriji, Energetika marketing, 2016.
Stojkov M; Šljivac, D; Topić, D ;Trupinić, K.; Alinjak, T; Arsoski, S; Klaić, Z; Kozak, D. Energetski učinkovita rasvjeta Sveučilište J.J. Strossmayera, Elektrotehnički fakultet Osijek, 2016.

1.12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
A. Sumper, A. Baggini, Electrical energy efficiency, Technologies and applications, Wiley, 2012.	1	1-3

1.13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

Through the institution’s quality assurance system.

[6] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

University of Rijeka
FACULTY OF ENGINEERING

COURSE DESCRIPTION		
Course instructor		
Name of the course	Intelligent manufacturing systems	
Study programme	Doctoral Study in the area of Technical Sciences, in the field of Electrical Engineering	
Status of the course	elective	
Year of study	1	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	15+0+0

1.1. Course objectives

The student will acquire theoretical and practical knowledge of modelling, simulation and analysis of intelligent complex systems, which is based on the study of specific structures and methods of application of modern architectures of production systems.

1.2. Course enrolment requirements

There are no conditions.

1.3. Expected learning outcomes

Identify trends in the modern production environment, and define system intelligence according to the individual concepts of modern production systems. Analyze and describe the application of reconfiguration and modularity methodology, with reference to the application of artificial intelligence methods to the optimization of production systems. Implement modern scientific methods for the implementation of virtual reality in the process of design and reconfiguration of the production system, and the relationship between man and production systems. Implement the modeling of complex systems using ready-made software packages.

1.4. Course content

Trend analysis in a modern production environment. CIM production analysis; defining the disadvantages of classic CIM production in a modern manufacturing environment. Multi-agent based intelligent manufacturing. Introducing new concepts to address deficiencies in the organization, sharing of information, and running classic CIM production systems; fractal, holonic and biological concept. Fractal Production Systems; Holon Production Systems; definition, Biological Production Systems; definition, basic individuals, problems, application. Introducing the concepts of mass customization and active reconfiguration of production systems. Production systems optimization methods based on artificial intelligence methods. Application of evolutionary computation and advanced machine learning methods in modelling and running modern production systems in real time. Object modelling of production systems. Software for modelling and control of modern production systems.

1.5. Manner of instruction		
	☒ lectures	☒ individual assignments
	☒ seminars and workshops	☐ multimedia and network
	☐ exercises	☐ laboratories
	☐ distance learning	☒ mentorship
	☐ fieldwork	☐ other

1.6. Comments

1.7. Student responsibilities

Attendance at lectures (consultations), project assignment and preparation and presentation of seminars.

1.8. Monitoring of student work[7]

Class attendance	0,5	Class participation		Seminar paper	2,5	Experimental work	
Written exam		Oral exam		Essay		Research	3
Project		Continuous assessment		Report		Practical work	
Portfolio							

1.9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

Attendance at lectures (consultations), project assignment and preparation and presentation of seminars.

1.10. Mandatory literature (at the time of submission of study programme proposal)

Lamb, F., 2013, ,Industrial Automation: Hands-on, McGraw-Hill Education,
Bonaccorso, G.; Fandango, A; Rajalingappaa S.: Python: Advanced Guide to Artificial Intelligence 2018.
Ueda, K., 1994, Biological Manufacturing Systems, Kogyochosakai Pub. Comp. Tokyo.
Bangsow S., 2010, Manufacturing Simulation with Plant Simulation and Simtalk: Usage and Programming with Examples and Solutions, Springer
LaRoux K. Gillespie, 2017., Design for Advanced Manufacturing: Technologies, and Processes, McGraw Hill Professional
William B. Bonvillian, William Bonvillian, Peter L. Singer, 2017, Advanced Manufacturing: The New American Innovation Policies, MIT Press

1.11. Optional/additional literature (at the time of submission of the study programme proposal)

Kovacs, G.L. & Haidegger, G., 1992, Integration in manufacturing: From FMS and FMC to CIM, Computer integrated manufacturing, Vol. 2, New York
Langton, C.G., editor, 1994, "Artificial Life III", Addison-Wesley.
Banks J., Carson S.J., Nelson L.B., Nicol M.D., 2009, Discrete-Event System Simulation (5th Edition), Prentice Hall

1.12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
Lamb, F., 2013, ,Industrial Automation: Hands-on, McGraw-Hill Education,	1	2
Bonaccorso, G.; Fandango, A; Rajalingappaa S.: Python: Advanced Guide to Artificial Intelligence 2018.	1	2
Ueda, K., 1994, Biological Manufacturing Systems, Kogyochosakai Pub. Comp. Tokyo.	1	2
Bangsow S., 2010, Manufacturing Simulation with Plant Simulation and Simtalk: Usage and Programming with Examples and Solutions, Springer.	1	2
Banks J., Carson S.J., Nelson L.B., Nicol M.D., 2009, Discrete-Event System Simulation (5th Edition), Prentice Hall	1	2

1.13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

Through the Institution's quality assurance system.

[7] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

University of Rijeka
FACULTY OF ENGINEERING

COURSE DESCRIPTION		
Course instructor		
Name of the course	**Intelligent manufacturing systems**	
Study programme	Doctoral Study in the area of Technical Sciences, in the field of Electrical Engineering	
Status of the course	elective	
Year of study	1	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	15+0+0

1.1. Course objectives

The student will acquire theoretical and practical knowledge of modelling, simulation and analysis of intelligent complex systems, which is based on the study of specific structures and methods of application of modern architectures of production systems.

1.2. Course enrolment requirements

There are no conditions.

1.3. Expected learning outcomes

Identify trends in the modern production environment, and define system intelligence according to the individual concepts of modern production systems. Analyze and describe the application of reconfiguration and modularity methodology, with reference to the application of artificial intelligence methods to the optimization of production systems. Implement modern scientific methods for the implementation of virtual reality in the process of design and reconfiguration of the production system, and the relationship between man and production systems. Implement the modeling of complex systems using ready-made software packages.

1.4. Course content

Trend analysis in a modern production environment. CIM production analysis; defining the disadvantages of classic CIM production in a modern manufacturing environment. Multi-agent based intelligent manufacturing. Introducing new concepts to address deficiencies in the organization, sharing of information, and running classic CIM production systems; fractal, holonic and biological concept. Fractal Production Systems; Holon Production Systems; definition, Biological Production Systems; definition, basic individuals, problems, application. Introducing the concepts of mass customization and active reconfiguration of production systems. Production systems optimization methods, based on artificial intelligence methods. Application of evolutionary computation and advanced machine learning methods in modelling and running modern production systems in real time. Object modelling of production systems. Software for modelling and control of modern production systems.

1.5. Manner of instruction	☒ lectures ☒ seminars and workshops ☐ exercises ☐ distance learning ☐ fieldwork	☒ individual assignments ☐ multimedia and network ☐ laboratories ☒ mentorship ☐ other
1.6. Comments		

1.7. Student responsibilities

Attendance at lectures (consultations), project assignment and preparation and presentation of seminars.

1.8. Monitoring of student work[8]

Class attendance	0,5	Class participation		Seminar paper	2,5	Experimental work	
Written exam		Oral exam		Essay		Research	3
Project		Continuous assessment		Report		Practical work	
Portfolio							

1.9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

Attendance at lectures (consultations), project assignment and preparation and presentation of seminars.

1.10. Mandatory literature (at the time of submission of study programme proposal)

Lamb, F., 2013, ,Industrial Automation: Hands-on, McGraw-Hill Education,
Bonaccorso, G.; Fandango, A; Rajalingappaa S.: Python: Advanced Guide to Artificial Intelligence 2018.
Ueda, K., 1994, Biological Manufacturing Systems, Kogyochosakai Pub. Comp. Tokyo.
Bangsow S., 2010, Manufacturing Simulation with Plant Simulation and Simtalk: Usage and Programming with Examples and Solutions, Springer
LaRoux K. Gillespie, 2017., Design for Advanced Manufacturing: Technologies, and Processes, McGraw Hill Professional
William B. Bonvillian, William Bonvillian, Peter L. Singer, 2017, Advanced Manufacturing: The New American Innovation Policies, MIT Press

1.11. Optional/additional literature (at the time of submission of the study programme proposal)

Kovacs, G.L. & Haidegger, G., 1992, Integration in manufacturing: From FMS and FMC to CIM, Computer integrated manufacturing, Vol. 2, New York
Langton, C.G., editor, 1994, "Artificial Life III", Addison-Wesley.
Banks J., Carson S.J., Nelson L.B., Nicol M.D., 2009, Discrete-Event System Simulation (5th Edition), Prentice Hall

1.12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
Lamb, F., 2013, ,Industrial Automation: Hands-on, McGraw-Hill Education,	1	2
Bonaccorso, G.; Fandango, A; Rajalingappaa S.: Python: Advanced Guide to Artificial Intelligence 2018.	1	2
Ueda, K., 1994, Biological Manufacturing Systems, Kogyochosakai Pub. Comp. Tokyo.	1	2
Bangsow S., 2010, Manufacturing Simulation with Plant Simulation and Simtalk: Usage and Programming with Examples and Solutions, Springer.	1	2
Banks J., Carson S.J., Nelson L.B., Nicol M.D., 2009, Discrete-Event System Simulation (5th Edition), Prentice Hall	1	2

1.13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

Through the Institution's quality assurance system.

[8] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

University of Rijeka
FACULTY OF ENGINEERING

COURSE DESCRIPTION		
Course instructor		
Name of the course	**Intelligent power systems – smart grids**	
Study programme	Doctoral Study in the area of Technical Sciences, in the field of Electrical Engineering	
Status of the course	elective	
Year of study	1	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	15+0+0

1.1. Course objectives

The subject aims to teach students about intelligent energy systems – Smart Grids and economic development, and economic aspects of the application of Smart Grids. Students will acquire knowledge in the field of Smart Grids, as well as the specifics of the energy market relations, the importance of the aspects of energy policy and its impact on the development of Smart Grids.

1.2. Course enrolment requirements

None.

1.3. Expected learning outcomes

Position the Smart Grid concept in the field of transmission and distribution power networks as a hub for distributed generation (renewable energy) integration,
Define the term Smart Grid in the context of energy market and analyze the energy policy used to encourage Smart Grid solutions,
Identify and classify optimization methods used in Smart Grids and Microgrids and analyze the economic feasibility of Smart Grids' implementation,
Create an example model of a Smart Grid or Microgrid, and critically assess, value and propose new models for planning and development of Smart Grids,
Explore the possibility of energy storage integration and demand response implementation in intelligent power systems.

1.4. Course content

The definition of intelligent power systems (Smart Grid). Overview of existing Smart Grid solutions. Development plan (roadmap) of Intelligent power systems and intelligent measurement systems (Smart Metering). Energy policy used to encourage Smart Grid. Economic evaluation of the Smart Grid implementation in a free energy market environment. Position of Smart Grid in the European energy legislation. Specific features regarding planning, modeling, calculation and operation of intelligent power systems. Procedures for monitoring, analysis and control of power systems in real time. SCADA systems. WAMS systems. Estimation of power system state and topology on the basis of measurement procurement and data analysis. Concept and design of Smart Grids and Microgrids. Demand response. Integration of RES and energy storage in intelligent power systems. The advantages of Smart Grids and Microgrids compared to traditional power system networks. Optmization methods in intelligent power systems and microgrids.

1.5. Manner of instruction		
	☒ lectures	☒ individual assignments
	☒ seminars and workshops	☐ multimedia and network
	☐ exercises	☐ laboratories
	☐ distance learning	☒ mentorship
	☐ fieldwork	☐ other

1.6. Comments	

1.7. Student responsibilities

Students are required to attend classes, write a seminar and a project and attend the oral exam. Seminar and project to be done in consultation with the teacher.

1.8. Monitoring of student work[9]

Class attendance	0,5	Class participation		Seminar paper	2	Experimental work	
Written exam		Oral exam	1	Essay		Research	0,5
Project	2	Continuous assessment		Report		Practical work	
Portfolio							

1.9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

Evaluation of students' work will be based on the results of his seminar work, project and oral exam.

1.10. Mandatory literature (at the time of submission of study programme proposal)

Daphne Mah, Peter Hills, Victor O. K. Li, Richard Balme: Smart Grid Applications and Developments, Springer-Verlag London, 2014.

1.11. Optional/additional literature (at the time of submission of the study programme proposal)

Stan Mark Kaplan: Smart Grid: Modernizing Electric Power Transmission and Distribution; Energy Independence, Storage and Security; Energy Independence and Security Act and Resiliency; Integra (Government Series), TheCapitol.Net, Inc., 2009.
Nikos Hadziargyriou: Microgrids, Arhitectures and Control, IEEE Press, Wiley, 2014.
Clark W. Gellings: The Smart Grid: Enabling Energy Efficiency and Demand Response, CRC Press; 1 edition, 2009.

1.12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
Daphne Mah, Peter Hills, Victor O. K. Li, Richard Balme: Smart Grid Applications and Developments, Springer-Verlag London, 2014.	1	

1.13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

Through the institution’s quality assurance system.

[9] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

University of Rijeka
FACULTY OF ENGINEERING

COURSE DESCRIPTION		
Course instructor		
Name of the course	**Intelligent robots and manipulators**	
Study programme	Doctoral Study in the area of Technical Sciences, in the field of Electrical Engineering	
Status of the course	elective	
Year of study	1	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	15+0+0

1.1. Course objectives

The student will gain insight into the current state of robotics, an overview of development trends, applications and directions of development and barriers along the way. Analyse trends in modern robotics. Define the laws of robotics. Position and importance of robotics in modern philosophy of technology. Analyse the construction of industrial robots. Define the operating mode of the robot. Analyse robot management strategies and algorithms. Define the integration of robots into production systems. Analyse robot application, current state and development trends.

1.2. Course enrolment requirements

There are no conditions.

1.3. Expected learning outcomes

Define and recognize the population, terminology, standardization and norms in robotics. Analyse the structure of industrial robots, with associated kinematics and dynamics. Define and describe robot intelligence, and implement advanced robot management strategies and algorithms. Using artificial methods to apply artificial intelligence to human-robot interaction and the interaction of biological and technical systems. Critically analyse the concepts of biorobotics, microbotics, and biologically inspired ideas and solutions in robotics.

1.4. Course content

Foundations of robotics: history, definitions, population, terminology, standardization and norms. The laws of robotics. Position and importance of robotics in modern philosophy of technology. Construction of industrial robots. Robotics kinematics and dynamics. Robot design (design, construction, simulation and calculation). Robot motions. Robot Workplace Organization. Robot Operating Mode: Pose-to-pose, continuous path. Robot end effectors and receivers (material, drives, sensors, flexibility, intelligence). Robot guidance strategy and algorithms. Artificial intelligence in path planning. Optimization of manipulator operations using evolutionary computation. Human-robot interaction. Interaction of biological and technical systems. Robot Programming and Learning. Robot Installation. Integration of robots into production systems. Application of the robot current state and development trends. Bio robotics. Micro robotics. Biologically inspired ideas and solutions in robotics. Generations of industrial robots. Robots in flexible manufacturing / assembly systems. Robotics as part of the CIM system.

1.5. Manner of instruction	☒ lectures ☒ seminars and workshops ☐ exercises ☐ distance learning ☐ fieldwork	☒ individual assignments ☐ multimedia and network ☐ laboratories ☒ mentorship ☐ other
1.6. Comments	-	

1.7. Student responsibilities

Attendance at lectures (consultations), project assignment and preparation and presentation of seminars.

1.8. Monitoring of student work[10]

Class attendance	0,5	Class participation		Seminar paper	2,5	Experimental work	
Written exam		Oral exam		Essay		Research	3
Project		Continuous assessment		Report		Practical work	
Portfolio							

1.9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

Attendance at lectures (consultations), project assignment and preparation and presentation of seminars.

1.10. Mandatory literature (at the time of submission of study programme proposal)

Francis X. Govers , 2018., Artificial Intelligence for Robotics: Build intelligent robots that perform human tasks using AI techniques, Packt Publishing
Arkapravo Bhaumik, 2018., From AI to Robotics: Mobile, Social, and Sentient Robots, CRC Press
Bonaccorso, G.; Fandango, A; Rajalingappaa S.: Python: Advanced Guide to Artificial Intelligence 2018.
Nikolic, G.; Katalinic, B.; Rogale, D.; Jerbic, B, & Cubric, G.: Roboti & Primjena u industriji tekstila i odjece, ISBN 978-953- 7105-22-8, Sveucilisni udzbenik, Tekstilno Tehnoloski Fakultet, Sveuciliste u Zagrebu, Zagreb, 2008; 336 pages
Robin R. Murphy, 2000, Introduction to AI Robotics, Massachusetts Institute of technology

1.11. Optional/additional literature (at the time of submission of the study programme proposal)

Nof, S.Y., Handbook of Industrial Robotics, 2nd Edition, 1999.
Bishop, R.H., The Mechatronics Handbook, 2002.
Thomas R. Kurfess, Robotics and Automation Handbook,London, 2005.

1.12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
Bonaccorso, G.; Fandango, A; Rajalingappaa S.: Python: Advanced Guide to Artificial Intelligence 2018.	1	
Nikolic, G.; Katalinic, B.; Rogale, D.; Jerbic, B, & Cubric, G.: Roboti & Primjena u industriji tekstila i odjece, ISBN 978-953-7105-22-8, Sveucilisni udzbenik, Tekstilno Tehnoloski Fakultet, Sveuciliste u Zagrebu, Zagreb, 2008; 336 pages	1	
Robin R. Murphy, 2000, Introduction to AI Robotics, Massachusetts Institute of technology	1	

1.13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

Through the Institution's quality assurance system.

[10] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

University of Rijeka
FACULTY OF ENGINEERING

COURSE DESCRIPTION		
Course instructor		
Name of the course	**Mathematical modeling and numerical methods**	
Study programme	Doctoral Study in the area of Technical Sciences, in the field of Electrical Engineering	
Status of the course	elective	
Year of study	1	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	15+0+0

1.1. Course objectives

Knowledge of the mathematical modeling based on the ordinary and partial differential equations and/or on the metamodel, necessary for solving problems in engineering. Knowledge of the chosen numerical methods for data analysis and the use of data-driven methods. Mathematical formulation of the problem, definition of the model and its solving with the aid of appropriate methods and software.

1.2. Course enrolment requirements

None.

1.3. Expected learning outcomes

Set up a mathematical formulation of the observed problem that is based on differential equations and/or on metamodel, justify the choice of the formulation, analyze the complexity and solvability of the problem.
Propose an appropriate numerical model and solve it with the aid of the existing software and/or by writing new software, or build the metamodel using the data-driven algorithms.
Critically evaluate and compare the obtained results and independently investigate the possible improvements.

1.4. Course content

Models based on ordinary differential equations. System dynamics and chaos. Numerical solution with the finite difference method. Runge-Kutta methods.
Models based on partial differential equation in fluid mechanics, thermodynamics and elasticity theory. Variational principle. Conservation laws for mass, momentum and energy applied to continuum mechanics. The concept of metamodels.
The chosen numerical methods for solving parabolic, hyperbolic and eliptic differential equations.
The chosen numerical methods for data analysis. Data-driven methods for building the metamodels.

1.5. Manner of instruction		
	☒ lectures	☒ individual assignments
	☒ seminars and workshops	☐ multimedia and network
	☐ exercises	☐ laboratories
	☐ distance learning	☒ mentorship
	☐ fieldwork	☐ other

1.6. Comments

1.7. Student responsibilities

Course attendance (consultations), solving project assignment, preparing and presenting the seminar.

1.8. Monitoring of student work[11]							
Class attendance	0,5	Class participation		Seminar paper	1,5	Experimental work	
Written exam		Oral exam		Essay		Research	
Project	4	Continuous assessment		Report		Practical work	
Portfolio							

1.9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

Course attendance, project, seminar paper.

1.10. Mandatory literature (at the time of submission of study programme proposal)

Strang, G.: Introduction to applied mathematics, Wellesley-Cambridge Press, Cambridge, 1986.
Chapra, S.C., Canale, R.P.: Numerical methods for engineers, McGraw Hill Book Co., 1989.
Press, W.H., Taukolsky, S.A., Flannery, B.P., W.T.: Numerical recipes, Cambridge Press, 1986.

1.11. Optional/additional literature (at the time of submission of the study programme proposal)

LeVeque, J.R., Finite Volume Methods for Hyperbolic Problems, Cambridge Univ. Press, 2002.
Cheney, W., Kincaid, D.: Numerical mathematics and computing, Thomson Brooks/Cole, 2004.

1.12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
Strang, G.: Introduction to applied mathematics, Wellesley-Cambridge Press, Cambridge, 1986.	1	1
Chapra, S.C., Canale, R.P.: Numerical methods for engineers, McGraw Hill Book Co., 1989.	1	1
Press, W.H., Taukolsky, S.A., Flannery, B.P., W.T.: Numerical recipes, Cambridge Press, 1986..	1	1

1.13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

Through the Institution's quality assurance system.

[11] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

COURSE DESCRIPTION		
Course instructor		
Name of the course		
Study programme	Doctoral Study in the area of Technical Sciences, in the field of Electrical Engineering	
Status of the course	elective	
Year of study	1	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	15+0+02

1.1. Course objectives

1.2. Course enrolment requirements

1.3. Expected learning outcomes

1.4. Course content

1.5. Manner of instruction	☒ lectures ☐ seminars and workshops ☐ exercises ☐ distance learning ☐ fieldwork	☒ individual assignments ☐ multimedia and network ☐ laboratories ☒ mentorship ☐ other
1.6. Comments		

1.7. Student responsibilities

1.8. Monitoring of student work[12]

Class attendance		Class participation		Seminar paper		Experimental work	
Written exam		Oral exam		Essay		Research	
Project		Continuous assessment		Report		Practical work	
Portfolio							

1.9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

1.10. Mandatory literature (at the time of submission of study programme proposal)

[12] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

1.11. Optional/additional literature (at the time of submission of the study programme proposal)
1.12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
R.C. Dugan; M.F. McGranaghan; S. Santoso; H.W. Beaty; Elektrical Power System Quality, McGraw-Hill, second edition, 2003	1	3-5

1.13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

COURSE DESCRIPTION		
Course instructor		
Name of the course	Methodology of the scientific-research work	
Study programme	Doctoral Study in the area of Technical Sciences, in the field of Electrical Engineering	
Status of the course	compulsory	
Year of study	1	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	15+0+0
1.1. Course objectives		
To familiarize student with the scientific method. To learn how to write and peer review scholarly works and research proposals. To understand organizational aspects of science as well as ethics in science. To		

learn basic skills required for a scientists..
1.2. Course enrolment requirements
None
1.3. Expected learning outcomes
To organize research. Critically evaluate methods used in science. To write a scientific paper and a research proposal. To conduct a peer review of a scholarly work.
1.4. Course content
Research and other elements of the scientific method. Critical thinking. Analysis and synthesis. Deduction and induction. Scientific communication. Elements of a scientific paper. Peer review. Open science. Preparing the research proposal. Writing and organizing a bibliography. Citations and References. Ph.D. thesis. Science and research in the Republic of Croatia and the world. Software tools for scientists. Ethics in science.

1.5. Manner of instruction	☒ lectures ☒ seminars and workshops ☐ exercises ☐ distance learning ☐ fieldwork	☒ individual assignments ☐ multimedia and network ☐ laboratories ☒ mentorship ☐ other
1.6. Comments	-	

1.7. Student responsibilities
Students are required to attend the classes/consultations. Each student will be given a project task. Students should write and present the seminar paper.
1.8. Monitoring of student work[13]

Class attendance	0,5	Class participation		Seminar paper	4	Experimental work	
Written exam		Oral exam		Essay		Research	
Project	1,5	Continuous assessment		Report		Practical work	
Portfolio							

1.9. Assessment of learning outcomes in class and at the final exam (procedure and examples)
Assessment and evaluation of students' work will be based on the results they achieve in solving their project task, seminar paper and the presentation of the seminar paper.
1.10. Mandatory literature (at the time of submission of study programme proposal)
Zelenika, R.: Metodologija i tehnologija izrade znanstvenog i stručnog djela,4. izd., Ekonomski fakultet u Rijeci, Rijeka, 2000.
1.11. Optional/additional literature (at the time of submission of the study programme proposal)
Churchill, H., Sanders, T. Getting Your Ph.D., SAGE Publications, Los Angeles, 2007. Schimel, J.: Writing Science, Oxford University Press, Oxford, 2012. Turabian, K.L.: A Manual for Writers of Research Papers, Theses, and Dissertations, 8th Ed., The University of Chicago Press, Chicago and London, 2010.
1.12. Number of assigned reading copies in relation to the number of students currently attending the course

[13] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

Title	*Number of copies*	*Number of students*
Zelenika, R.: Metodologija i tehnologija izrade znanstvenog i stručnog djela,4. izd., Ekonomski fakultet u Rijeci, Rijeka, 2000.	20	20

1.13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences
Through the Institution's quality assurance system.

COURSE DESCRIPTION		
Course instructor		
Name of the course	Mixed signal processing	
Study programme	Doctoral Study in the area of Technical Sciences, in the field of Electrical Engineering	
Status of the course	elective	
Year of study	1	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	15+0+0
1.1. Course objectives		
Course objective is introduction to analog and digital signal processing systems. Attention will be set on analysis of existing solutions as well as on finding possibilities for new solutions with enhanced		

characteristics.

1.2. Course enrolment requirements

None.

1.3. Expected learning outcomes

After passing of exam, student will be able to:
Make analysis and design of new analog high order filters in different structures with enhanced characteristics.
Make analysis and design of new switch capacitors filters with enhanced characteristics.
Make analysis and design of new circuits for A/D and D/A signal conversion with enhanced characteristics.

1.4. Course content

Analog and digital signal processing systems. Filters based on operational and transconduction amplifiers. Switch capacitor filters. A/D converters, principe of operation. D/A converters, principe of operation.

1.5. Manner of instruction	☒ lectures ☐ seminars and workshops ☐ exercises ☐ distance learning ☐ fieldwork	☒ individual assignments ☐ multimedia and network ☒ laboratories ☒ mentorship ☐ other
1.6. Comments		

1.7. Student responsibilities

Students should attend to class, do necessary laboratory work, make given research and make project assignment.

1.8. Monitoring of student work[14]

Class attendance	0.5	Class participation		Seminar paper	0.5	Experimental work	
Written exam		Oral exam		Essay	3	Research	
Project	2	Continuous assessment		Report		Practical work	
Portfolio							

1.9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

Student's assessment is based on done activities: laboratory work, research results and project.

1.10. Mandatory literature (at the time of submission of study programme proposal)

Wai-Kai Chen, The Circuits and Filters Handbook, second edition, CRC PRESS, 2003.

1.11. Optional/additional literature (at the time of submission of the study programme proposal)

M.S.Ghausi, K.R.Laker, Modern Filter Design, Noble Publishing, 2003.

1.12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
The Circuits and Filters Handbook, second edition	1	

[14] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

1.13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences		
Through Faculty's quality control system.		

COURSE DESCRIPTION		
Course instructor		
Name of the course	**Modelling of electrical power transmission and distribution systems**	
Study programme	Doctoral Study in the area of Technical Sciences, in the field of Electrical Engineering	
Status of the course	elective	
Year of study	1	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	15+0+0
1.1. Course objectives		

The objectives of the course are to provide theoretical and practical knowledge to the students for solving different technical problems in the fields of planning, design and control of distribution system, as well as analysis and design of low-voltage electrical installations.
1.2. Course enrolment requirements
None.
1.3. Expected learning outcomes
Develop mathematical models of transmission and distribution network elements and apply them for network calculations in specific operating conditions Analyse and revise existing methods for transmission and distribution network planning and development; select and apply new methods Analyse and develop solutions for protection, automation, control and asset management of transmission and distribution networks Propose new solutions for consumer plants and installations; analyse the risks and hazards inherent with electric power, and propose relevant safety practices Analyse, propose and implement modern solutions for electrical power transmission, distribution and consumption systems
1.4. Course content
Power transmission and distribution system structure. Consumption of electrical energy. Customer's load profiles. Methods for calculation of peak load. Power line or power transformer loads. Mathematical models for transmission and distribution power line, power transformer and customer's load profile. Calculation methods for load flow and voltage profile in normal (steady state) and disturbed states. Calculation with symmetrical and asymmetrical loads. Distributed generation. Planning and design of transmission networks. Planning and design of distribution networks. Optimal transmission and distribution system control (Asset management). Economics of transmission and distribution system. Protection, automation and control of distribution system. Electric power quality. Low-voltage electrical installations planning and design. Smart electrical installations. Risks and hazards of electrical energy. Protection and security at work.

1.5. Manner of instruction	☒ lectures ☐ seminars and workshops ☐ exercises ☐ distance learning ☐ fieldwork	☒ individual assignments ☐ multimedia and network ☐ laboratories ☒ mentorship ☐ other
1.6. Comments		

1.7. Student responsibilities

Students are required to attend classes, write a seminar and a project and access the oral exam. Seminar and project to be done in consultation with the teacher.

1.8. Monitoring of student work[15]

Class attendance	0,5	Class participation		Seminar paper	1	Experimental work	
Written exam		Oral exam	2,5	Essay		Research	
Project	2	Continuous assessment		Report		Practical work	
Portfolio							

[15] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

1.9. Assessment of learning outcomes in class and at the final exam (procedure and examples)
Assessment and evaluation of students' work will be done based on the results of their seminar, project and oral exam.
1.10. Mandatory literature (at the time of submission of study programme proposal)
Available scientific papers from journals with high impact factor are used.
1.11. Optional/additional literature (at the time of submission of the study programme proposal)
J.D. Glover, M.S. Sarma, T.J. Overbye: Power System Analysis & Design, Cenegage Learning 2008. N.D. Tleis: Power Systems Modelling and Fault Analysis, Elsevier 2008. T. A. Short: Electric Power Distribution Handbook, 2nd Edition, CRC Press, 2014. E. Lakervi, E.J. Holmes: Electricity Distribution Network Design, Peter Pereginns Ltd, London, 1995. Kersting,W.H.: Distribution System Modelling and Analysis, CRC Press, London, 2002.
1.12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*

1.13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences
Through the institution’s quality assurance system.

COURSE DESCRIPTION		
Course instructor		
Name of the course	Nonstationary signal analysis and processing	
Study programme	Doctoral Study in the area of Technical Sciences, in the field of Electrical Engineering	
Status of the course	elective	
Year of study	1	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	15+0+0

1.1. Course objectives

The students will get familiar with the basic concepts of nonstationary signals analysis and processing using time- frequency distributions (TFDs). TFD design techniques, measures of signal quality representation based on its TFDs, as well as the algorithms for signal nonstationary parameters estimation will be studied in details.

1.2. Course enrolment requirements

None.

1.3. Expected learning outcomes

Define the signal, its key parameters and properties in the time-frequency domain
Describe the advantages of signal time-frequency analysis
Describe the heuristic methods for time-frequency distributions (TFDs) definitions, including the spectrogram and the Wigner-Ville distribution
Define the Quadratic class of TFDs and its properties
Describe various interference terms present in a TFD and the methods for their suppression
Apply various TFD design techniques
Define concentration and complexity measures for TFDs
Estimate the instantaneous frequency of a signal from its time-frequency representations
Apply time-frequency tools in the analysis and processing of real-life nonstationary signals

1.4. Course content

Time-frequency concepts; advantages of time-frequency representations of signals. The formulation and characteristics of signals in the time-frequency domain; nonstationarity, the Hilbert transform, the analytic signal, monocomponent and multicomponent signals, the signal instantaneous frequency. Heuristic methods of time-frequency distribution (TFDs) definitions; the Wigner-Ville distribution, the short-time Fourier transformation, the spectrogram. Theory of the Quadratic class of time-frequency distributions; definitions, properties, and examples. Design of quadratic time-frequency distributions; interference terms, the ambiguity function, desirable properties for practical applications, TFDs with separable filters. Adaptive TFDs and higher-order TFDs. Concentration and complexity measures for time-frequency representations. Time-frequency techniques for signal instantaneous frequency estimation. Examples of real-life signals time-frequency analysis. Software packages for nonstationary signals time-frequency analysis.

1.5. Manner of instruction	☐ lectures ☐ seminars and workshops ☐ exercises ☐ distance learning ☐ fieldwork	☒ individual assignments ☒ multimedia and network ☐ laboratories ☒ mentorship ☐ other
1.6. Comments	---	

1.7. Student responsibilities

The students are required to submit the project, and take part in the oral exam.

1.8. Monitoring of student work[16]

Class attendance	0,5	Class participation		Seminar paper		Experimental work	
Written exam		Oral exam	1	Essay		Research	2,5
Project	2	Continuous		Report		Practical work	

[16] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

		assessment					
Portfolio							

1.9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

Assessment and evaluation of students' work will be based on the results they achieve in the project and the oral exam.

1.10. Mandatory literature (at the time of submission of study programme proposal)

B. Boashash, ed., *Time-Frequency Signal Analysis and Processing: A Comprehensive Review*, 2nd ed., Academic Press, 2016.

1.11. Optional/additional literature (at the time of submission of the study programme proposal)

1.12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
B. Boashash, ed., Time-Frequency Signal Analysis and Processing: A Comprehensive Review, 2nd ed., Academic Press, 2016.	2	5

1.13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

Through the Institution's quality assurance system.

COURSE DESCRIPTION		
Course instructor		
Name of the course	Optimization methods	
Study programme	Doctoral Study in the area of Technical Sciences, in the field of Electrical Engineering	
Status of the course	elective	
Year of study	1	
ECTS credits and manner of	ECTS credits	6

instruction	Number of class hours (L+E+S)	15+0+0

1.1. Course objectives

Identification of optimization problems in engineering practice and scientific research. Mathematically set optimization problems and solve them using appropriate methods and software.

1.2. Course enrolment requirements

None.

1.3. Expected learning outcomes

Set up a mathematical formulation of an optimization problem, analyze and evaluate the complexity and solvability of the problem based on the formulation.
Investigate the possibilities of applying particular methods to a given optimization problem and choose the appropriate method.
Build a computer code that represents the implementation of the goals and constraints of the optimization problem (goal function).
Explore problem-solving capabilities by using ready-made software and / or writing your own implementation of the optimization method.
Solve the optimization problem and analyze the results of optimization, identify the causes of possible handicaps in implementation and formulation, improve the accuracy of the results with combination and variation of methods and approaches.

1.4. Course content

Optimization problems in technology. Optimization problem formulation: optimization variables, objectives, and constraints. Problems of optimal management of stationary phenomena. Problems of optimal management of non-stationary phenomena. Optimal design problems. Model parameter calibration problems. Optimization problems of permutation type and optimal clustering. Treatment of restrictions.
Optimization methods and the notion of a black box. Methods based on the objective function gradient. Methods of direct search and sample search. Combinatorial methods. Heuristic methods. Evolutionary optimization methods. Swarm intelligence based methods. Software for solving optimization problems.

1.5. Manner of instruction	☒ lectures ☒ seminars and workshops ☐ exercises ☐ distance learning ☐ fieldwork	☒ individual assignments ☐ multimedia and network ☐ laboratories ☒ mentorship ☐ other
1.6. Comments		

1.7. Student responsibilities

Course attendance (consultations), solving project assignment, preparing and presenting the seminar.

1.8. Monitoring of student work[17]

Class attendance	0,5	Class participation		Seminar paper	1,5	Experimental work	
Written exam		Oral exam		Essay		Research	
Project	4	Continuous assessment		Report		Practical work	

[17] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

Portfolio							

1.9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

Course attendance, project, seminar paper.

1.10. Mandatory literature (at the time of submission of study programme proposal)

Winston, W. L.: Operations Research Application and Algorithms, Duxbury Press, Belmont, 1993
Press, W. H. at al.: Numerical Recipes in C, 2nd ed. University Press, Cambridge, 1990
Goldberg, E. D.: Genetic Algorithms in Search, Optimization, and Machine Learning, Addison-Wesley Publishing Company, New York, 1989

1.11. Optional/additional literature (at the time of submission of the study programme proposal)

1.12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
Winston, W. L.: Operations Research Application and Algorithms, Duxbury Press, Belmont, 1993	1	1
Press, W. H. at al.: Numerical Recipes in C, 2nd ed. University Press, Cambridge, 1990.	1	1
Goldberg, E. D.: Genetic Algorithms in Search, Optimization, and Machine Learning, Addison-Wesley Publishing Company, New York, 1989.	1	1

1.13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

Through the Institution's quality assurance system.

COURSE DESCRIPTION	
Course instructor	
Name of the course	Photonic Devices
Study programme	Doctoral Study in the area of Technical Sciences, in the field of Electrical Engineering
Status of the course	elective
Year of study	1

ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	15+0+0

1.1. Course objectives

Superior knowledge of the photonic devices, technology and state-of-the arts in photonics.
Deepened (superior) knowledge of the physical concept needed to understand the working principles of photonic elements. Monitoring, selection and knowledge of scientific literature identifying unresolved issues. Designing and conducting original scientific research (within the project) by numerical modelling based on the physics and technology of photonic devices, and an explanation of the physical phenomena crucial for the operation of photonic devices. Presentation of the results of research project to colleagues and experts in the field. Ability to continue independent research in line with challenges in the field of photonics.

1.2. Course enrolment requirements

Enrolment in the current academic year of postgraduate doctoral study. Recommended basic knowledge on semiconductor devices and optoelectronics.

1.3. Expected learning outcomes

Preknowledge, gained from lectures and from literature, for the further development of models, methods and research procedures in the field of photonics. By applying the selected scientific method, contribute to the understanding of the principles of operation and use of modern photonic devices. In the narrower field of photonics (project assignment), specific research work with the hypothesis set, and accepting or rejecting the set hypothesis, and regularly reporting on the achieved.

1.4. Course content

Introduction: Overview of the state-of-the art in photonics and the trend in photonics development.
Light; Models and light properties.
Photonic device materials. Optical process in semiconductors, absorption and emission of light, defects and their influence on the devices physical properties, recombinations of free charge carriers.
Light sources: LED, laser, LD; Photodetectors: Photodiodes, Photovoltaic sources: Solar cells. Fiber optics.
Integrated photonics: APS, biosensors. Numerical modelling of physical processes and potonics devices.
Photonic devices technology.
Color detection and recognition with application in image sensors, biosensors. Methods of photodiodes and solar cells parameter extraction.
The possibile updates and upgrades of the course contents with specific photonics topics in project works.

1.5. Manner of instruction	☒ lectures ☐ seminars and workshops ☐ exercises ☐ distance learning ☐ fieldwork	☒ individual assignments ☐ multimedia and network ☐ laboratories ☒ mentorship ☐ other
1.6. Comments		

1.7. Student responsibilities

Active participation in teaching, drafting and presenting a project assignment to other students, independently finding and studying literature, and identifying problems in the scientific field. Designing project work in consultation with the teacher. Possible publication of a scientific paper resulting from a project assignment.

1.8. Monitoring of student work[18]

Class attendance	0.5	Class participation		Seminar paper		Experimental	

[18] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

						work	
Written exam		Oral exam	2.5	Essay		Research	1
Project	2	Continuous assessment		Report		Practical work	
Portfolio							

1.9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

Assessment and evaluation based on the literature found, the results of the project work, the oral exam.

1.10. Mandatory literature (at the time of submission of study programme proposal)

S. M.Sze,K.K. Ng, Physics of Semicondutor Devices, J.Wiley &Sons, Inc.2007.
S. L. Chuang, Physics of Photonic Devices, J.Wiley &Sons, Inc.2009.
B.E.A. Saleh, M.C. Teich, Fundamentals of Photonics, J.Wiley &Sons, Inc.2007.
A. Kitai, Principles of Solar Cells, LEDs and Related Devices, J. Wiley& Sonea Ltd, 2019.
H Yu, M. Yan, X. Huang, CMOS Integrated Lav-on-Chip system for personlized biomedical diagnosis

1.11. Optional/additional literature (at the time of submission of the study programme proposal)

1. K. Tomizawa, Numerical Simulation of Submicron Semiconductor Devices, Artech House, Boston, London1993.
EEE Transactions on Electron Devices, IEEE Electron Device Letters.
Scientific papers IEEE, IAP, Elsevier, example Solid-State Electronics etc.

1.12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
S. M.Sze,K.K. Ng, Physics of Semicondutor Devices, J.Wiley &Sons, Inc.2007.	1	3
S. L. Chuang, Physics of Photonic Devices, J.Wiley &Sons, Inc.2009.	1	3
B.E.A. Saleh, M.C. Teich, Fundamentals of Photonics, J.Wiley &Sons, 2007.	1	3
A. Kitai, Principles of Solar Cells, LEDs and Related Devices, J. Wiley& Sons Ltd, 2019.	1	3
H Yu, M. Yan, X. Huang, CMOS Integrated Lav-on-Chip system for personlized biomedical diagnosis	1	3

1.13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

Through the institution's quality assurance system.

COURSE DESCRIPTION	
Course instructor	
Name of the course	**Power system optimization**
Study programme	Doctoral Study in the area of Technical Sciences, in the field of Electrical Engineering
Status of the course	elective

Year of study	1	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	15+0+0

1.1. Course objectives

Expand students' knowledge in the field of modern power systems operation, and present possible approaches related to application of optimization techniques. Apply a suitable optimization technique for problem solving. Definition of the objective function and associated constraints. Solve optimization problems using existing algorithms and available optimization tools.

1.2. Course enrolment requirements

None.

1.3. Expected learning outcomes

Independently search and analyse scientific literature in the domain of power system optimization.
Model an optimization problem by defining the objective function and corresponding constraints, thus finding the solution using ready-made algorithms and computer tools.
Systematize and analyse obtained solutions and choose the final solution of the optimization problem.
Critically consider new optimization methods for power system optimization.

1.4. Course content

Basic terms and definitions. Introduction to optimization and mathematical programming. Formulation of the optimization problem - modelling of the transmission grid, generators, consumption and energy storage facilities. Problem types and optimization methods. Overview of optimization algorithms applicable to power systems. Linear, mixed integer and nonlinear programming. Intelligent search methods. Optimum power flows. Reactive power optimization. Unit commitment and economic dispatch in power system. Application of readymade algorithms and computer tools. Optimization of power system operation in extended real-time.

1.5. Manner of instruction	☒ lectures ☒ seminars and workshops ☐ exercises ☐ distance learning ☐ fieldwork	☒ individual assignments ☐ multimedia and network ☐ laboratories ☒ mentorship ☐ other
1.6. Comments		

1.7. Student responsibilities

Students are required to attend classes, write a seminar and access the oral exam.

1.8. Monitoring of student work[19]

Class attendance	0.5	Class participation		Seminar paper	2	Experimental work	
Written exam		Oral exam	1.5	Essay		Research	
Project	2	Continuous assessment		Report		Practical work	
Portfolio							

1.9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

[19] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

Evaluation of students' work will be based on the results of his seminar work, project and oral exam.
1.10. Mandatory literature (at the time of submission of study programme proposal)
Jizhong Zhu: Optimization of power system operation, Wiley, IEEE Press, Hoboken, New Jersey, 2015.
1.11. Optional/additional literature (at the time of submission of the study programme proposal)
S.A.-H. Soliman, A.-A.H. Mantawy, Modern optimization techniques with applications in Electric power systems, Springer 2012. A.J. Momoh, Electric power system applications and optimization, CRC Press, Taylor&Francis Group, Boca Raton, Florida, 2009.
1.12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
Jizhong Zhu: Optimization of power system operation, Wiley, IEEE Press, Hoboken, New Jersey, 2015.	1	1-3

1.13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences
Through the institution’s quality assurance system.

COURSE DESCRIPTION	
Course instructor	
Name of the course	**Reliability of technical systems**
Study programme	Doctoral Study in the area of Technical Sciences, in the field of Electrical Engineering
Status of the course	elective

Year of study	1	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	15+0+0

1.1. Course objectives

A thorough knowledge of content related to the reliability of technical systems. Developing a student's ability to independently analyze and evaluate the reliability of a technical system.

1.2. Course enrolment requirements

None.

1.3. Expected learning outcomes

Creating and evaluating new concepts, facts and principles in reliability theory and developing an experimental method for determining reliability. Using advanced knowledge and skills in modelling the reliability of systems with independent components and analyzing the reliability of systems with dependent components. Development of new ideas through the analysis of safety and risk of technical systems, the parameter of reliability as well as the design of fault trees of complex technical systems.

1.4. Course content

Basic concepts of reliability theory: component reliability, failure probability density functions, and failure rates. Reliability modelling of systems with independent components. (Serial, parallel and combined configuration). Mathematical models for calculating the reliability and availability of complex systems. Reliability of systems with dependent components. Backup system. Markov models. System with repairable components. Safety and risk analysis of technical systems. Concept of technical system efficiency, definition of efficiency parameters. Reliability analysis and failure tree analysis of complex technical systems. Experimental methods for determining reliability.

1.5. Manner of instruction	☒ lectures ☐ seminars and workshops ☐ exercises ☐ distance learning ☐ fieldwork	☒ individual assignments ☐ multimedia and network ☐ laboratories ☒ mentorship ☐ other
1.6. Comments	-	

1.7. Student responsibilities

Attendance in class (consultations), project assignment, preparation and presentation of seminars, and oral examination.

1.8. Monitoring of student work[20]

Class attendance	0,5	Class participation		Seminar paper	1,5	Experimental work	
Written exam		Oral exam	0,5	Essay		Research	3,0
Project		Continuous assessment		Report	0,5	Practical work	
Portfolio							

1.9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

Assessment of active participation in the class, evaluation of the project assignment. Oral exam.

[20] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

1.10. Mandatory literature (at the time of submission of study programme proposal)
Mangey Ran, Reliability Engineering – Methods and Application, CRC Press, Boca Raton, 2019 Briolini, A., Reliability Engineering – Theory and Practice, 8th Edition, Springer, Berlin, 2017.
1.11. Optional/additional literature (at the time of submission of the study programme proposal)
Vujanović, N., Teorija pouzdanosti tehničkih sistema, Beograd, 1987 Hrvatska norma HRN 61730, „Matematički izrazi za pouzdanost, raspoloživost, sposobnosti održavanja i održavanje“, 2008.
1.12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
Mangey Ran, Reliability Engineering – Methods and Application, CRC Press, Boca Raton, 2019	1	2
Briolini, A., Reliability Engineering – Theory and Practice, 8th Edition, Springer, Berlin, 2017.	1	2

1.13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences
Through the established quality assurance system of the Faculty.

COURSE DESCRIPTION	
Course instructor	
Name of the course	**Selected chapters on energy components and systems of renewable energy sources**
Study programme	Doctoral Study in the area of Technical Sciences, in the field of Electrical Engineering
Status of the course	elective

Year of study	1	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	15+0+0

1.1. Course objectives

The objectives of the course are to train students for critical analysis, implementation and planning of production plants using renewable energy sources (RES) and to indicate the global importance of RES as compared to conventional energy sources regarding RES's ecological advantage, technical and technological characteristics, legislative and economic/financial indicators and problems.

1.2. Course enrolment requirements

None.

1.3. Expected learning outcomes

Apply modern technologies in the field of renewable energy sources and assess RES potential,
Apply methods of techno-economic analysis by RES projects development,
Apply modern concepts for RES interconnection with the utility grid,
Analysis and assessment of RES impact on the electric power system,
Apply methods for energy efficiency improvement.

1.4. Course content

Renewable energy source definition. Solar energy. Eolic energy. Hydro energy. Biomass, waste and biofuel energy. Geothermal energy. Other renewable energy sources. Techno-economic analysis of production plants using RES. Issues concerning RES interconnection with the public utility grid (transmission and distribution grid). RES production plant operation impact on the public utility grid. Energy efficiency definition and practical implementation.

1.5. Manner of instruction	☒ lectures ☐ seminars and workshops ☐ exercises ☐ distance learning ☐ fieldwork	☒ individual assignments ☐ multimedia and network ☐ laboratories ☒ mentorship ☐ other
1.6. Comments		

1.7. Student responsibilities

Students are required to attend classes, write a seminar and a project and access the oral exam. Seminar and project to be done in consultation with the teacher.

1.8. Monitoring of student work[21]

Class attendance	0,5	Class participation		Seminar paper	2	Experimental work	
Written exam		Oral exam	1,5	Essay		Research	
Project	2	Continuous assessment		Report		Practical work	
Portfolio							

1.9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

Assessment and evaluation of students' work will be done on the basis of the results of their seminar,

[21] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

project and oral exam.

1.10. Mandatory literature (at the time of submission of study programme proposal)

Lj. Majdandžić; Obnovljivi izvori energije, Graphis, Zagreb, 2008.
P. Kulišić; Novi izvori energije-sunčana energija i energija vjetra, Školska knjiga, Zagreb, 1991.
A. Rub: Power Electronics for Renewable Energy Systems, Transportation and Industrial Applications, IEEE, Wiley, 2014

1.11. Optional/additional literature (at the time of submission of the study programme proposal)

Grupa autora: SUNEN - Program korištenja energije sunca, Energetski institut Hrvoje Požar, Zagreb.
Grupa autora: ENWIND - Program korištenja energije vjetra, Energetski institut Hrvoje Požar, Zagreb.
Grupa autora: BIOEN - Program korištenja energije biomase i otpada, Energetski institut Hrvoje Požar, Zagreb.
Grupa autora: MAHE - Program izgradnje malih hidroelektrana, Energetski institut Hrvoje Požar, Zagreb.
Grupa autora: GEOEN - Program korištenja geotermalne energije, Energetski institut Hrvoje Požar, Zagreb.

1.12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
Lj. Majdandžić; Obnovljivi izvori energije, Graphis, Zagreb, 2008	0	3-5
P. Kulišić; Novi izvori energije-sunčana energija i energija vjetra, Školska knjiga, Zagreb, 1991	0	3-5

1.13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

Through the institution's quality assurance system.

COURSE DESCRIPTION	
Course instructor	
Name of the course	
Study programme	Doctoral Study in the area of Technical Sciences, in the field of Electrical Engineering
Status of the course	elective

Year of study	1	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	15+0+0

1.1. Course objectives

1.2. Course enrolment requirements

1.3. Expected learning outcomes

1.4. Course content

1.5. Manner of instruction	☒ lectures ☒ seminars and workshops ☐ exercises ☐ distance learning ☐ fieldwork	☒ individual assignments ☐ multimedia and network ☐ laboratories ☒ mentorship ☐ other
1.6. Comments		

1.7. Student responsibilities

1.8. Monitoring of student work[22]

Class attendance		Class participation		Seminar paper		Experimental work	
Written exam		Oral exam		Essay		Research	
Project		Continuous assessment		Report		Practical work	
Portfolio							

1.9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

1.10. Mandatory literature (at the time of submission of study programme proposal)

1.11. Optional/additional literature (at the time of submission of the study programme proposal)

1.12. Number of assigned reading copies in relation to the number of students currently attending the course

[22] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

Title	*Number of copies*	*Number of students*
R. Siegwart et al, Introduction to Autonomous Mobile Robots (second edition), MIT Press, Cambridge, 2011	1	1
1.13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences		
Through the institution's quality assurance system		

COURSE DESCRIPTION		
Course instructor		
Name of the course	**Statistical methods and stochastic processes**	
Study programme	Doctoral Study in the area of Technical Sciences, in the field of Electrical Engineering	
Status of the course	elective	
Year of study	1	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	15+0+0
1.1. Course objectives		

Knowledge about basic principles in statistical methods needed for the analysis of data obtained from different engineering problems. Introduction to stochastic processes. Data manipulation and the analysis of statistical data by applying acquired methods within statistical engineering software's, modeling of engineering problems as stochastic processes.
1.2. Course enrolment requirements
None.
1.3. Expected learning outcomes
Independently explore the possibilities of applying different statistical methods or stochastic processes in the observed problem. Set up a problem formulation for the application of the selected methods, implement the methods, critically evaluate and compare the obtained results. Review the behavior of the system by applying theoretical knowledge and independently investigate possible improvements of the system.
1.4. Course content
Elements of statistical inferences: Bayesian methods, sample based methods, statistical estimation, parametric and nonparametric tests, analysis of variance, multidimensional random variables, regression and correlation analysis. Matrix methods in statistics. Statistical methods by using statistical software. Stochastic processes. Markov processes and Markov chains. Birth and death processes. Queuing systems. Stationary stochastic processes. Correlation theory. Some applications in engineering.

1.5. Manner of instruction	☒ lectures ☒ seminars and workshops ☐ exercises ☐ distance learning ☐ fieldwork	☒ individual assignments ☐ multimedia and network ☐ laboratories ☒ mentorship ☐ other
1.6. Comments		

1.7. Student responsibilities

Course attendance (consultations), solving project assignment, preparing and presenting the seminar.

1.8. Monitoring of student work[23]

Class attendance	0,5	Class participation		Seminar paper	1,5	Experimental work	
Written exam		Oral exam		Essay		Research	
Project	4	Continuous assessment		Report		Practical work	
Portfolio							

1.9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

Course attendance, project, seminar paper.

1.10. Mandatory literature (at the time of submission of study programme proposal)

Montgomery, D.C., Runger, G.C.: Applied Statistics and Probability for Engineers, Wiley, New York, 2003.
Devore, J.L.: Probability and Statistics for Engineering and the Sciences, Duxbury Press, 1995.
Yates, Goodman, Probability and Stochastic Processes: a friendly intorduction for electrical and computer engineers, Wiley, 2005.

[23] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

1.11. Optional/additional literature (at the time of submission of the study programme proposal)
Leon-Garcia, Alberto: Probability, statistics, and random processes for electrical engineering, Pearson Education, Inc., 2008. Elezović, N.: Statistika i procesi, FER, Element, Zagreb 2008.
1.12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
Montgomery, D.C., Runger, G.C.: Applied Statistics and Probability for Engineers, Wiley, New York, 2003.	1	1
Devore, J.L.: Probability and Statistics for Engineering and the Sciences, Duxbury Press, 1995.	1	1
Yates, Goodman, Probability and Stochastic Processes: a friendly intorduction for electrical and computer engineers, Wiley, 2005.	1	1

1.13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences
Through the Institution's quality assurance system.

COURSE DESCRIPTION		
Course instructor		
Name of the course	**The elements of energy transition**	
Study programme	Doctoral Study in the area of Technical Sciences, in the field of Electrical Engineering	
Status of the course	elective	
Year of study	**1**	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	15+0+0
1.1. Course objectives		

Training the trainees for these extraordinary times for global energy. As societies are coming to terms with the need to build a different kind of energy system than we've had in the past – one based not only on affordability and reliability, but also sustainability – a series of major trends are profoundly reshaping the energy sector. These include continued cost reductions for clean energy technologies, notably solar PV, wind and batteries, and the rapidly increasing importance of digital technologies and electricity.
1.2. Course enrolment requirements
None.
1.3. Expected learning outcomes
Conceptualize the growing share of renewable energy sources in electricity systems; Work on the flexibility of electrical energy systems; Model a future electricity market; Propose new energy market regulation policies; Design platform collaboration between private sector and policy makers to develop market reform. Collaborate in the development of technical-socio-economic analyzes to stimulate investments in renewable energy sources and grids and increase the use of innovative technologies.
1.4. Course content
Key elements of the energy transition: 1. Supporting the pathway for transforming the global energy sector from fossil to zero-carbon. 2. Creating a stimulating technical, technological, economic and social context for energy transition. 3. Key features that make the electrical system central to energy transition. 4. An innovative model for assessing the socio-economic effects of the energy transition by 2030 in the EU28 and Croatia (S-E Europe). 5. Effect of energy transition on existing technological value chains in the European Union and Croatia (S-E Europe). 6. Creating new digital services in the energy transition. 7. Effects of energy transition in terms of industrial production and employment in the European Union and Croatia (S-E Europe). 8. The transition of energy by electrification and will improve the environment and human health. 9. Challenges and benefits associated with energy transition: preserving Europe's industrial competitiveness and avoiding negative distributional effects. 10. Identifying energy policy issues in order to effectively address the challenges associated with energy. transition and redistribute its benefits by ensuring a "for all" transition.

1.5. Manner of instruction	☒ lectures ☒ seminars and workshops ☐ exercises ☐ distance learning ☐ fieldwork	☒ individual assignments ☐ multimedia and network ☐ laboratories ☒ mentorship ☐ other
1.6. Comments		

1.7. Student responsibilities
Students are required to attend classes, create a seminar paper and project, and take an oral exam. Seminar work and project should be conducted in consultation with the subject teacher.
1.8. Monitoring of student work[24]

Class attendance	0,5	Class participation		Seminar paper	1	Experimental work	
Written exam	2	Oral exam	0,5	Essay		Research	

[24] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

Project	2	Continuous assessment		Report		Practical work	
Portfolio							

1.9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

Assessment and evaluation of students' work will be done on the basis of the results of the seminar paper, the project and the oral examination.

1.10. Mandatory literature (at the time of submission of study programme proposal)

C. Corazza, A. Višković, Svjetlo ili mrak: Koncept čovjek – energija, pogled iz Bruxellesa, Zagreb: IMO – Liderpress, 2010.
G. Piani, A. Višković, B. Saftić, Protokol iz Kyota; Ostvaranje i budući razvoj, zakonodavstvo, strategije, tehnologije, Zagreb, Graphis, 2011.

1.11. Optional/additional literature (at the time of submission of the study programme proposal)

European Commission, "Attitudes of European citizens towards the environment", 2017.

1.12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
C. Corazza, A. Višković, Svjetlo ili mrak: Koncept čovjek – energija, pogled iz Bruxellesa, Zagreb: IMO – Liderpress, 2010.	4	
G. Piani, A. Višković, B. Saftić, Protokol iz Kyota; Ostvaranje i budući razvoj, zakonodavstvo, strategije, tehnologije, Zagreb, Graphis, 2011.	6	

1.13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

Through the established quality monitoring system of the Faculty.