JOSIP JURAJ STROSSMAYER UNIVERSITY OF OSIJEK

FACULTY OF ELECTRICAL ENGINEERING, COMPUTER SCIENCE AND INFORMATION TECHNOLOGY OSIJEK

POSTGRADUATE DOCTORAL STUDY PROGRAMME IN ELECTRICAL ENGINEERING

Branch: Power Engineering

Branch: Communications and Informatics

Osijek, October 2016

1. Study description

1.1. Admission criteria

Candidates who graduated from the Faculty of Electrical Engineering, Computer Science and Information Technology Osijek (FERIT) or hold a degree in other faculties of electrical and/or computer engineering from Croatian universities with a grade point average (GPA) on an undergraduate and a graduate study level of at least 3.8 are eligible to enrol in the postgraduate doctoral study programme.

If a GPA is lower than 3.8 but not lower than 3.0, a candidate needs to be among the best 10% of students in one's generation. Pursuant to the proposal of the Doctoral Committee, the Faculty Council can make an exception and approve for a candidate to enrol in the postgraduate doctoral study programme based on the recommendation letters of two university professors or based on research results a candidate did during or upon graduating.

Candidates holding a Master's degree in Mathematics/Physics/Informatics from faculties of science, technical sciences and engineering faculties from Croatian universities with a GPA on an undergraduate and a graduate study level of at least 3.8 are eligible to enrol in the postgraduate doctoral study programme.

If a GPA is lower than 3.8 but not lower than 3.0, pursuant to the proposal of the Doctoral Committee, the Faculty Council can make an exception and approve for a candidate to enrol in the postgraduate doctoral study programme based on the recommendation letters of two university professors or based on research results a candidate did during or upon graduating.

In such case, the Doctoral Committee will organise an entrance examination and/or additional exams from the undergraduate and graduate study programme of the Faculty of Electrical Engineering, Computer Science and Information Technology Osijek.

Candidates holding a Master of Science degree with a specialisation in Electrical or Computer Engineering are eligible to enrol in the postgraduate doctoral study programme.

Candidates holding a Master's degree in Electrical or Computer Engineering from foreign universities are eligible to enrol in the university postgraduate doctoral study programme after undergoing the process of recognition of academic diplomas.

Speaking one world language is mandatory for all candidates.

Candidates are admitted to the university postgraduate doctoral study programme pursuant to the selection procedure rank. The Faculty Council, based on the proposal issued by the Doctoral Committee, announces an invitation for applications concerning the admission to the postgraduate doctoral study programme. The vacancy announcement contains the information on scientific fields and branches determined by the curriculum of the postgraduate doctoral study programme. The vacancy announcement is published in media and on the Faculty website. The vacancy announcement contains the information on admission criteria, selection procedure, available places and tuition fees.

The final decision on the implementation of the postgraduate doctoral study programme, pursuant to the vacancy announcement, is made by the Faculty Council.

An applicant wishing to enrol in the postgraduate doctoral study programme has to submit an application form in a specified timeframe. The application form has to include the following:

- an applicant's personal information including the residential address;
- a certified copy of a certificate of nationality or a proof of citizenship;
- a certified copy of a graduate, four-year university undergraduate (pre-Bologna) or a postgraduate Master degree diploma;
- a diploma supplement related to undergraduate and graduate or four-year university undergraduate (pre-Bologna) study programmes or a transcript of records;
- recommendation letters of two university professors if a candidate's GPA is lower than 3.8;
- Curriculum Vitae;
- proposition of a scientific field, branch of the study programme, supervisor and the explanation of the scientific field and branch selection.

A list of the necessary documents is to be published in postgraduate doctoral study programme vacancy announcement. Applications are to be sent to the postal address of the Faculty of Electrical Engineering, Computer Science and Information Technology Osijek or brought in person.

1.2. Criteria and selection procedure

If there are more candidates than vacant postgraduate doctoral study programme places, a selection procedure will be established. During the selection procedure, the Doctoral Committee will evaluate a grade point average of all grades candidates earned during their undergraduate and graduate study programmes or four-year university undergraduate (pre-Bologna) study programmes. Additionally, the Doctoral Committee will evaluate published scientific and expert papers, submitted and accepted patents and participation in expert projects. Considering all submitted materials (including the recommendation letters by two university professors), pursuant to the report done by the Doctoral Committee, the Faculty Council makes the final admission decision.

1.3. Competencies students would achieve upon completion of the postgraduate doctoral study programme

Upon completion of the postgraduate doctoral study programme in Electrical Engineering, students will be able to conduct scientific projects, develop and apply new technologies as well as educate students.

Branch Power Engineering

The postgraduate doctoral study programme in Power Engineering extends knowledge relative to energy generation, transmission, distribution, consumption and management previously acquired

at the graduate study programme. Furthermore, the study programme is aimed at providing a comprehensive study of physical processes and a theoretical background with respect to the aforementioned issues, as well as scientific methods used for development, construction, management and maintenance planning of the electric power system.

Branch Communications and Informatics

The postgraduate doctoral study programme in Communications and Informatics broadens the prior knowledge of information theory, information networks, control, programming and processing algorithms in networks, analyses and applications of modulation processes, state-of-the-art radiocommunications systems, theory, analysis and synthesis methods as well as design of embedded, distributed and expert computer systems and software solution for system and application software. Moreover, students gain theoretical and scientific knowledge covering the fields of analysis, optimisation, planning and design of communications and information systems, radiocommunications systems, multimedia systems, process control systems, intelligent and broadband integrated services digital networks, and modern computer architecture and its software.

2. ACADEMIC CREDIT SYSTEM AND DURATION OF STUDY

2.1. Structure and organisation of the study programme

The postgraduate doctoral study programme in Electrical Engineering lasts for 6 semesters during which students earn 180 ECTS credits. The programme is available as both a full-time and part-time study mode. The full-time study mode lasts for 3 years. Students enrolled in the part-time study mode can fulfil their academic requirements in two academic years instead of two semesters (one academic year). There are several types of classes, namely lectures, individual work with a supervisor, writing research papers and participating in various research projects.

The postgraduate doctoral study programme consists of fundamental, fundamental field-specialised and field-specialised courses and corresponding ECTS credits (1 ECTS credit represents a workload of 30 hours).

In order to be awarded an academic degree of Doctor of Science, students have to earn at least 480 ECTS credits. Based on credits earned on the previous levels of education, ECTS credits are recognised as follows:

- Students who completed undergraduate studies in duration of 6 semesters followed by graduate studies in duration of 4 semesters (total of 10 semesters) at the Faculty of Electrical Engineering, Computer Science and Information Technology Osijek (previously known as the Faculty of Electrical Engineering Osijek) are rewarded with 300 ECTS credits;
- Students who completed pre-Bologna undergraduate studies in duration of 8 semesters at the Faculty of Electrical Engineering Osijek are rewarded with 240 ECTS credits;

- Students who completed pre-Bologna undergraduate studies in duration of 9 semesters at the Faculty of Electrical Engineering Osijek are rewarded with 270 ECTS credits;
- Students holding a Master of Science degree in Electrical or Computer Engineering from the Faculty of Electrical Engineering Osijek are rewarded with 390 ECTS credits, i.e. up to 90 ECTS credits while the rest of credits have to be earned at the postgraduate doctoral study programme (depending on research activities, i.e. published papers during the postgraduate Master of Science degree programme);
- Students who graduated from faculties of Electrical and/or Computer Engineering on other Croatian universities are rewarded with ECTS credits by the Doctoral Committee. The decision is based on a number of semesters on an undergraduate and a graduate level (usually, a number of semesters multiplied by 30);
- Students holding a degree in Mathematics, Physics, Informatics or other related studies from Croatian universities are rewarded with ECTS credits by the Doctoral Committee. The decision is based on a number of semesters on a graduate level (usually, a number of semesters multiplied by 30);
- Students who graduated from foreign universities are rewarded with ECTS credits by the Doctoral Committee. The decision is based on a number of semesters (usually, a number of semesters multiplied by 30).

Methods of acquiring necessary differential ECTS credits are determined by the Faculty Council upon the proposal made by the Doctoral Committee.

During the postgraduate doctoral study programme, a student must achieve at least 180 ECTS credits or a total of at least 480 ECTS credits by passing exams and conducting scientific research.

By taking courses and passing exams, students must earn at least 26.67% and at most 30% of the necessary additional ECTS credits as follows:

- at least 12 ECTS credits by passing fundamental exams in the first semester;
- at least 12 ECTS credits by passing fundamental field-specialised exams in the second semester;
- at least 24 ECTS credits by passing field-specialised exams in the second, third and fourth semester.

By conducting scientific research, students must earn at least 70% and at most 73.33% of the necessary additional ECTS credits as follows:

- 5 ECTS credits are awarded to a student for a paper in scientific fields related to the research area of the doctoral dissertation that is published in conference proceedings not cited in citation databases (up to 2 papers are recognised in this category);
- 10 ECTS credits are awarded to a student for a paper in scientific fields related to the research area of the doctoral dissertation that is published in a journal cited in citation databases which need not be listed in categories A and B pursuant to the Regulations on conditions for the election to scientific titles, Official Gazette No 84 of 11 July 2005 (already in other citation databases), or in internationally reviewed conference

proceedings cited in citation databases which must be listed in categories A and B pursuant to the aforementioned Regulations;

- 20 ECTS credits are awarded to a student for a paper in scientific fields related to the research area of the doctoral dissertation that is published in a journal cited in citation databases (category B pursuant to the Regulations on conditions for the election to scientific titles, Official Gazette No 84 of 11 July 2005);
- 40 ECTS credits are awarded to a student for a paper in scientific fields related to the research area of the doctoral dissertation that is published in a journal ranked in the third or the fourth quartile (i.e., Q3 or Q4) cited in citation databases Current Contents (CC), Science Citation Index (SCI) or Science Citation Index Expanded (SCI-Exp.) (category A pursuant to the Regulations on conditions for the election to scientific titles, Official Gazette No 84 of 11 July 2005);
- 60 ECTS credits are awarded to a student for a paper in scientific fields related to the research area of the doctoral dissertation that is published in a journal ranked in the second quartile (i.e., Q2) cited in citation databases Current Contents (CC), Science Citation Index (SCI) or Science Citation Index Expanded (SCI-Exp.) (category A pursuant to the Regulations on conditions for the election to scientific titles, Official Gazette No 84 of 11 July 2005);
- 80 ECTS credits are awarded to a student for a paper in scientific fields related to the research area of the doctoral dissertation that is published in a journal ranked in the first quartile (i.e., Q1) cited in citation databases Current Contents (CC), Science Citation Index (SCI) or Science Citation Index Expanded (SCI-Exp.) (category A pursuant to the Regulations on conditions for the election to scientific titles, Official Gazette No 84 of 11 July 2005).

A candidate earns a maximum number of ECTS credits for papers published by 1-3 authors, and 300/n% of the given ECTS credits for papers published by n=4 or more authors.

• 10 ECTS credits are awarded to a student for passing a PhD qualifying examination that must be taken before the end of the fourth semester.
• 10 ECTS credits are awarded to a student for his/her participation in a research project in the field of his/her doctoral dissertation in duration of one or more years (active participation of the student in a research project is confirmed by a project manager in a written report).
• 10 ECTS credits are awarded to a student for conducting research in the field of his/her doctoral dissertation at an internationally recognised research institution in duration of 3 or more months (the student submits a statement from the institution at which he/she stayed, as well as a report on his/her stay and research that shall be signed by a research leader).
• 30 ECTS credits are awarded to a student for dissertation topic approval and expected scientific contributions of a doctoral dissertation.

2.2 Course of study

After the expiry date of the call for applications for enrolment in the postgraduate doctoral study programme, the Doctoral Committee proposes and the Faculty Council appoints a supervisor to every candidate. A candidate and his/her supervisor together choose courses before enrolling in the first semester, whereas MSc degree holders and their supervisors do that before enrolling in the fourth semester.

A candidate develops his/her own syllabus within the postgraduate doctoral study programme by selecting and entering courses in the way and scope stipulated by the doctoral degree study programme curriculum. The selection of courses should be approved by the supervisor, and finally confirmed by the Doctoral Committee.

For the purpose of creating the conditions aimed at successful meeting of obligations and commitments referring to the postgraduate doctoral study programme as well as conduction of research, conditions are stipulated for enrolment in subsequent semesters as follows:

- To be able to enrol in the third semester, a PhD student shall pass additional examinations and acquire at least 20 ECTS credits by passing examinations or/and by publishing results of his/her scientific research.
- To be able to enrol in the fifth semester, a PhD student shall acquire the total of at least 70 ECTS credits by passing examinations (i.e., by passing first- and second-semester examinations), by publishing results of his/her scientific research and by passing the PhD qualifying examination.
- To be able to initiate the procedure for approval of the dissertation topic, a PhD student must pass all examinations, including the PhD qualifying examination, and earn at least 120 ECTS credits (of which min. 60 ECTS credits must be earned by publishing his/her research results, where at least one (1) research paper in the field of the doctoral dissertation topic must be published in an international scientific journal of category A (SCI, SCI-Exp., CC)).

2.3. The advisory and guidance scheme in the doctoral study programme

The advisory and guidance scheme in the doctoral study programme is accomplished through mentorship, and the operation of the head of the Postgraduate doctoral study programme and the Doctoral Committee. The Doctoral Committee takes care of the general conditions of study and individual progress of PhD students.

Supervisor

After the expiry date of the call for applications for enrolment in the postgraduate doctoral study programme, a supervisor elected in a scientific-educational title is appointed to every PhD student by the Faculty Council. A supervisor shall help a PhD student with his/her research and take care of publication of research papers.

In the procedure for approval of the dissertation topic either the appointed supervisor is confirmed or other supervisor whose research falls into the scope of the dissertation topic is appointed. If necessary, a co-supervisor may also be appointed to a PhD student for the purpose of meeting the best conditions possible for dissertation guidance. The Faculty Council appoints a supervisor and a co-supervisor who must be professors employed at the Faculty and elected in scientific-educational titles. Exceptionally, individual candidates may have persons not employed at the Faculty appointed as their supervisors, but they must be elected in scientific-educational or scientific titles in the scientific field of the postgraduate doctoral study programme and involved in the execution of the postgraduate doctoral study programme.

2.4. Courses a PhD student can take from other postgraduate doctoral study programmes

Students can take certain courses offered by other postgraduate doctoral study programmes at Josip Juraj Strossmayer University of Osijek, or other Croatian and foreign universities. Such courses are approved by the Doctoral Committee after consideration of the student's proposal co-signed by the supervisor.
Criteria and conditions for the transfer of ECTS credits for courses from other postgraduate study programmes at the Josip Juraj Strossmayer University of Osijek or at other universities that have been approved will be regulated by mutual agreements between the Faculty of Electrical Engineering, Computer Science and Information Technology Osijek and the faculty the selected course is taught at.

2.5. Classes held in a foreign language

If necessary, all classes can be conducted in English.

2.6. Conditions for returning to study after a break

A student who has lost his/her status of a PhD student due to a break in study may choose to continue studying, provided that no more than three years have passed since the break in study occurred. If a student continues with his/her postgraduate doctoral studies after having a break, the Doctoral Committee determines the number of ECTS credits acknowledged for the continuation of the doctoral studies as well as student obligations.

2.7. Conditions under which a PhD student is entitled to the right of certifying the completed part of doctoral studies

Upon his/her request, a PhD student may be provided a letter certifying courses attended and examinations passed within the framework of the postgraduate doctoral study programme.

2.8. Ways and conditions for doctoral study completion by dissertation defence

2.8.1. Procedure for approval of the dissertation topic

The procedure for approval of the dissertation topic may be initiated by a candidate after he/she has achieved a minimum of 120 ECTS credits (i.e., a total of 420 ECTS credits) and passed all examinations enrolled in the postgraduate doctoral study programme, including the PhD qualifying examination. Within the aforementioned 120 ECTS credits, a candidate is required to obtain a minimum of 60 ECTS credits by publishing his/her research results, where at least one (1) research paper in the field of the doctoral dissertation topic must be published in an international scientific journal of category A (SCI, SCI-Exp., CC).

A student and the proposed supervisor initiate the procedure for approval of the dissertation topic by submitting an application to the Doctoral Committee, i.e. the Faculty Council, proposing the dissertation topic. The application must contain the following:

- a suggested dissertation title both in Croatian and in English;
- a detailed explanation of the topic;
- a clearly defined research objective and plan;
- research methodology;
- expected original scientific contributions of the dissertation.

A candidate shall submit the following together with the application:

- a student record book;
- a list and copies of published papers;
- a short biography with a description of the candidate's research and professional activity;
- a statement confirming that the PhD procedure has not been initiated at any other institution in Croatia or abroad.

The Doctoral Committee establishes whether the conditions for initiating the procedure for approval of the dissertation topic have been met. It proposes to the Faculty Council the composition of the Dissertation Topic Approval Committee. If the Doctoral Committee finds out that the application does not contain necessary documentation, the PhD student will be given a deadline, not longer than 30 days, to supplement his/her application.

Thesis proposal defence shall be completed in consultation with the supervisor by the end of the 5th year of study at the latest.

The candidate who meets the conditions for initiating the procedure for approval of the dissertation topic shall defend the thesis proposal in front of the Dissertation Topic Approval Committee who shall evaluate the certainty of achieving the overall expected original scientific contribution more closely.

Thesis proposal defence must take place within 90 days of submitting the application for approval of the dissertation topic. The period from 16 July to 31 August is not included in the outlined deadline.

The Faculty Council is to make the final decision on approving or rejecting the dissertation topic based on the report written by the Dissertation Topic Approval Committee and on the proposal

submitted by the Doctoral Committee. During the procedure regarding the approval of the doctoral dissertation topic, the Faculty Council may also appoint a co-mentor to the PhD student.

2.8.2. Submission and defence of the doctoral dissertation

The candidate whose doctoral dissertation topic has been approved may submit his/her doctoral dissertation for evaluation if she/he has acquired a minimum of 480 ECTS credits, out of which are at least 180 ECTS credits during the postgraduate doctoral study programme. In addition, the candidate must have at least two (2) papers published in journals listed in category A (SCI, SCI-Exp., CC).

The doctoral dissertation shall be prepared and formatted in accordance with the publicly available guidelines issued by the Doctoral Committee.
The candidate must submit the doctoral dissertation for evaluation within a maximum of ten (10) years from the date of dissertation topic approval at the Faculty Council meeting. The doctoral dissertation topic, which has not been submitted for approval within the stipulated time period, is subject to a re-approval procedure.
The candidate initiates the doctoral dissertation evaluation procedure by submitting an application to the Doctoral Committee, i.e., the Faculty Council, in written form, which shall also be co-signed by the proposed supervisor.
With the application the candidate has to submit seven (7) unbound copies of the completed dissertation including the list of published papers and a photocopy of the published papers which have not been submitted in previous doctoral procedures.
During the process of dissertation evaluation and defence and prior to the submission of the bound copies, the Student Administration Office has to submit one unbound copy to the Faculty Library to be at public disposal.
The Doctoral Dissertation Evaluation Committee members must submit their report within 90 days after receipt of the dissertation. The period between 16 July and 30 August is not taken into account when defining the report submission deadline.

The Doctoral Dissertation Evaluation Committee submits the signed report to the Doctoral Committee. In the report, the Dissertation Evaluation Committee may recommend:

- Dissertation approval;
- Corrections to be made in the dissertation and future repeated evaluation;
- Dissertation rejection.

In all three cases the Committee has to substantiate its decision. A positive decision has to include an explicit statement on the achieved original scientific contributions and a scientific field to which the doctoral dissertation belongs.
At the Faculty Council meeting, the President of the Doctoral Dissertation Evaluation Committee (only in exceptional cases the candidate's supervisor or a Committee member) gives a report on doctoral dissertation assessment focusing on the achieved original contributions to science.

If the Faculty Council concludes that the report submitted by the Doctoral Dissertation Evaluation Committee does not give grounds for evaluating the doctoral dissertation, it can appoint additional members of the Committee and require them to submit separate reports, or to appoint a new Doctoral Dissertation Evaluation Committee that should reconsider and reassess the dissertation in question, as well as submit their report to the Faculty Council.
If the Faculty Council accepts the positive evaluation of the doctoral dissertation, as a rule, in the same meeting and following the proposal of the Doctoral Committee, it shall appoint the Doctoral Dissertation Defence Committee consisting of five (5) members and two (2) deputy members. Doctoral Dissertation Evaluation Committee members can also be members of the Doctoral Dissertation Defence Committee.
In case of a negative recommendation by the Doctoral Dissertation Evaluation Committee, the Faculty Council can decide to expand the Committee by new members, appoint a new Doctoral Dissertation Evaluation Committee or suspend the doctoral procedure.

Doctoral dissertation defence is open to public. The date of the public defence is agreed upon by the supervisor and the Doctoral Dissertation Defence Committee and the candidate. The Student Administration Office must be informed about the date of the public defence at least 15 days prior to the defence date.
The Student Administration Office notifies both the candidate and the Doctoral Dissertation Defence Committee of the date and venue at least seven (7) days prior to the defence date.
Doctoral dissertation defence is announced in written and electronic form on the notice board and the website of the Faculty at least seven (7) days prior to the defence date.

Following the oral defence the Committee informs the candidate of the overall grade for the defence. The grades are:

- Defended by unanimous decision of the Committee members;
- Defended by a majority vote of the Committee members;
- Did not defend.

The dissertation is defended only once.
The minutes of the defence are taken by a Student Administration officer in charge of the postgraduate studies**.**
Upon a successful defence, the candidate adds an additional sheet to his/her dissertation containing the names of the Doctoral Dissertation Evaluation Committee and Doctoral Dissertation Defence Committee members and the defence date.
Within one month of the defence the candidate has to submit nine (9) bound copies of the dissertation to the Faculty Secretariat.
The Faculty Secretariat delivers one copy of the dissertation to: Josip Juraj Strossmayer University of Osijek, Faculty department, or the institution at which the dissertation has been done respectively, Faculty Archive, City and University Library in Osijek, National and University Library in Zagreb, and also to the supervisor, president and member of the Doctoral Dissertation Evaluation Committee. In addition, the dissertation is published in the national Digital Academic Archives and Repositories (DABAR).

Based on a positive decision of the Doctoral Dissertation Defence Committee, the University of Osijek issues a degree certificate or a diploma testifying the awarded academic degree of Doctor of Science. The diploma is awarded by the Rector at the graduation ceremony.

A PhD student who completes the Postgraduate doctoral study programme in Power Engineering is awarded the following title:

PhD, major field: Technical Sciences, scientific field: Electrical Engineering, branch: Power Engineering

A PhD student who completes the Postgraduate doctoral study programme in Communications and Informatics is awarded the following title:

P**hD, major field: Technical Sciences, scientific field: Electrical Engineering, branches: Telecommunications and Informatics, or Radiocommunications** (depending on the decision reached by the Doctoral Dissertation Evaluation Committee).

2.9. Maximum duration of study of the doctoral study programme from enrolment to its completion

A full-time Postgraduate doctoral study programme lasts for three years, which, in case of justified circumstances and by providing a written explanation, can be extended to five years based on the decision made by the Doctoral Committee.
A part-time Postgraduate doctoral study programme lasts for five years maximum, which, in case of justified circumstances and by providing a written explanation, can be extended to seven years based on the decision made by the Doctoral Committee.
A full-time PhD student loses his/her right to study if he/she fails to defend his/her doctoral dissertation 5 years after enrolment at the latest.

A part-time PhD student loses his/her right to study if he/she fails to defend his/her doctoral dissertation 10 years after enrolment at the latest.

A PhD student can be granted a leave of absence due to the following:

- pregnancy;
- maternity/parental leave pursuant to special regulations;
- a medical condition which prevents the student from fulfilling the obligations during the studies;
- international student exchange lasting longer than 60 days during classes, in case the student does not acquire ECTS credits during the exchange programme, and in other justified circumstances which are in line with the decision made by the Faculty Council/Doctoral Committee.

The student can exercise his/her right to leave of absence by submitting a written request with accompanying documentation supporting the justification of the request to the Doctoral Committee within 30 days starting from the day the reason for requesting the leave of absence started. The approval of the leave of absence is granted by the Doctoral Committee.

During the leave of absence, the student is allowed to take exams in those courses he/she fulfilled his/her obligations. The leave period is not included in the time limit for study completion.

3.1. LIST OF COURSES

3.1. Joint fundamental courses for the postgraduate doctoral study programme in Electrical Engineering

3.1.1. Joint fundamental courses (enrolled in the first semester)

Code	Lecturer	Course	Workload Total	L	S, LP	ECTS
ZZT101	R. Galić	Probability and Statistics - Application	45	30	15	6
ZZT103	I. Galić	Signal Theory	45	30	15	6
ZZT104	T. Marošević	Linear Integral and Discrete Transformations	45	30	15	6
ZZT105	Z. Lacković	Technical Systems Management	45	30	15	6
ZZT106	T. Hunjak	Decision Making Theory	45	30	15	6
ZZT107	S. Rimac-Drlje	Research Methods	45	30	15	6
ZEUK23	R. Scitovski	Evolutionary Algorithms and Applications	45	30	15	6

L – lectures
S, LP- seminar paper, laboratory practice

Scientific field: Electrical Engineering
Branch: Power Engineering

3.2. List of courses

3.2.1. Branch fundamental courses (enrolled in the second semester)

Code	Lecturer	Course	Workload Total	L	S, LP	ECTS
ZETE01	L. Jozsa	Power System Optimisation	45	30	15	6
ZETE02	S. Nikolovski	Reliability and Availability of Electric Power System	45	30	15	6
ZETE03	P. Marić	Transformers Management	45	30	15	6
ZETE04	T. Mrčela	Advanced Electrical Materials	45	30	15	6
ZETE05	M. Zeljko	Electricity Market	45	30	15	6
ZETE06	J. Pihler	Switchgear and High Voltage Engineering	45	30	15	6
ZEUE08	D. Šljivac	Distributed Generation of Electrical Energy From Renewable Sources	45	30	15	6

3.2.2. Scientific-specialisation courses (enrolled in the second, third and fourth semester)

Winter Semester (third semester)

Code	Lecturer	Course	Workload Total	L	S, LP	ECTS
ZEUE01	Ž. Hederić	Fault Detection in AC Electrical Machines	45	30	15	6
ZEUE02	Ž. Hederić	Automatic Electric Drives	45	30	15	6
ZEUE03	D. Pelin	Applications of Power Electronic Systems in Power Engineering	45	30	15	6
ZEUE04	P. Marić	Power System Stability	45	30	15	6
ZEUE05	Z. Baus	Development in High-Voltage SF6 Gas-Insulated Substations-GIS	45	30	15	6
ZEUK13	K. Miličević	Non-linear Electrical Networks and Deterministic Chaos	45	30	15	6
ZEUK08	K. Nenadić	Intelligent Manufacturing Systems	45	30	15	6
ZEUK11	R. Cupec	Intelligent Robotic Systems	45	30	15	6

Summer semesters (second and fourth semester)

Code	Lecturer	Course	Workload Total	L	S, LP	ECTS
ZEUE06	S. Nikolovski	Monitoring and Power Quality	45	30	15	6
ZEUE07	M. Stojkov	Transients in Power Systems	45	30	15	6
ZEUE09	Ž. Hederić	Dynamics of Electrical Machines	45	30	15	6
ZEUE10	K. Miličević	Complete Measurement Result and Decision Making	45	30	15	6
ZEUE11	D. Šljivac	Power System Planning in Open Electricity Market Conditions	45	30	15	6
ZEUE14	Z. Klaić	Advanced Power Networks	45	30	15	6
ZEUE15	D. Topić	Modelling and Control of Renewable Energy Power Plants	45	30	15	6

Scientific field: Electrical Engineering
Branch: Communications and Informatics

3.3. List of courses

3.3.1. Branch fundamental courses (enrolled in the second semester)

Code	Lecturer	Course	Workload Total	L	S, LP	ECTS
ZETK01	T. Švedek	CMOS Application Specific Integrated Circuits-ASIC	45	30	15	6
ZETK03	D. Žagar	Analysis and Synthesis of Communication Protocols	45	30	15	6
ZETK04	A. Baumgartner	Object-oriented Programming	45	30	15	6

ZETK06	G. Martinović	Resource and Performance Management in Computer Systems	45	30	15	6
ZETK07	K. E. Nyarko, R. Grbić	Algorithms and Graphs	45	30	15	6
ZETK08	T. Rudec	Fast Algorithms for NP Hard Problems	45	30	15	6

3.3.2. Scientific-specialisation courses (enrolled in the second, third and fourth semester)

Winter semester (third semester)

Code	Lecturer	Course	Workload Total	L	S, LP	ECTS
ZEUK01	D. Žagar	Internet Technology	45	30	15	6
ZEUK02	S. Rupčić	Antenna Arrays Analysis	45	30	15	6
ZEUK03	S. Rupčić	Noise in Radiocommunications	45	30	15	6
ZEUK04	V. Majstorović	Information Technology and Entrepreneurship	45	30	15	6
ZEUK05	Ž. Hocenski	Modern Computer Architecture	45	30	15	6
ZEUK06	T. Keser	Embedded Computer Systems	45	30	15	6
ZEUK07	J. Job	Databases and Computer Networks	45	30	15	6
ZEUK08	K. Nenadić	Intelligent Manufacturing Systems	45	30	15	6
ZEUK09	G. Martinović , S. Rimac-Drlje	Multimedia Computer Systems	45	30	15	6
ZEUK10	I. Galić	Computer Graphics	45	30	15	6
ZEUK11	R. Cupec	Intelligent Robotic Systems	45	30	15	6
ZEUK12	M. Colnarič	Real-time Computer Systems in Control	45	30	15	6
ZEUK26	I. Aleksi T. Matić Ž. Hocenski D. Kraus	Computer Systems for Real-time Processing	45	30	15	6
ZEUK27	R. Scitovski	Algorithms for Data Clustering	45	30	15	6

Summer semesters (second and fourth semester)

Code	Lecturer	Course	Workload Total	L	S, LP	ECTS
ZEUK13	S. Rimac-Drlje	Digital Videocommunication	45	30	15	6
ZEUK14	T. Švedek	Modern Radio-Communication System Architectures	45	30	15	6
ZEUK15	D. Žagar	Quality of Service in the Internet	45	30	15	6
ZEUK16	M. Vranješ	Wideband Networks for Multimedia Services	45	30	15	6
ZEUK17	V. Žiljak	XML Publishing Technologies	45	30	15	6
ZEUK18	V. Majstorović	Development and Application of ERP System	45	30	15	6
ZEUK19	Ž. Hocenski	Multiprocessor and Parallel Systems	45	30	15	6
ZEUK20	D. Blažević, I. Lukić	Software Quality Assurance	45	30	15	6

ZEUK25	I. Crnković	Component-based Software Systems	45	30	15	6
ZEUK28	R. Grbić, J. Job	Data Science	45	30	15	6
ZEUK29	G. Martinović	Computing Environments and Data Analysis Methods	45	30	15	6

3.4. Course description

ZZT101 PROBABILITY AND STATISTICS - APPLICATION	
Lecturer:	**Dr. Radoslav Galić, Full Professor**
ECTS credits:	6 ECTS lecture attendance: 1.5 ECTS seminar paper: 3 ECTS oral examination: 1.5 ECTS
Knowledge and skills acquired:	Introduction to statistical terminology and laws, design of statistical models and application of statistical methods in engineering, process control, quality control, etc. Preparation for a lifelong learning process and the use of mathematical tools in application.
Course contents:	Algebra of events. Probability. Random variable. Discrete probability distributions. Continuous probability distributions. Two-dimensional distributions. Correlation. Empirical distributions. Sample theory. Parameter estimation. Interval estimation. Testing parameter hypotheses. Chi-square test. Time sequences. Logical trend. Regression analysis.
Obligatory literature:	1. R. Galić, Vjerojatnost , ETF, Osijek, 2004 2. R. Galić, Statistika, ETF, Osijek, 2004 3. Ž. Pauše, Uvod u matematičku statistiku, Školska knjiga, Zagreb, 1995 4. G. M. Clarke, D. Cooke, A Basic Course in Statistics, Arnold, London, 1992
Recommended additional literature:	1. I. Pavlić, Statistička teorija i primjena, Tehnička knjiga, Zagreb, 2000 2. Ž. Pauše, Vjerojatnost, Školska knjiga, Zagreb, 2004
Prerequisites:	Calculus I and Calculus II
Teaching methods:	Lectures (30 hours), individual work with students pertaining to their respective seminar paper (15 hours).
Student assessment and examination methods:	Seminar paper and oral examination.
Course assessment:	Doctoral committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

ZZT103 SIGNAL THEORY	
Lecturer:	**Dr. Irena Galić, Associate Professor**
ECTS credits:	6 ECTS lecture attendance: 1.5 ECTS seminar paper: 3 ECTS oral examination: 1.5 ECTS
Knowledge and skills acquired:	Knowledge of the continuous-time and discrete-time signal characteristics and applications of the signal processing methods in different engineering areas.
Course contents:	Models of continuous-time and discrete-time signals. Linear operations. Fourier transformations: FS, FT, DTFS, DTFT. Signal duration, bandwidth and dimensionality. Systems and convolutions. Causality and Paley-Wiener criteria. Spectral analysis. Continuous-time and discrete-time random signals. Correlation and spectrum. Noise. Optimal filtering and signal parameters estimation. Detection. Digital signal transmission errors. Time-frequency processing. Wavelet transformation. Applications.
Obligatory literature:	1. F. de Coulon: Signal Theory and Processing, Artech House, Dedham, 1986
Recommended additional literature:	1. A. Papoulis: Signal Analysis, McGraw-Hill, 1977 2. G. Strang, T. Nguyen: Wavelets and Filter Banks, Wellesley, Cambridge University Press 1996
Prerequisites:	Signals and systems
Teaching methods:	Lectures (30 hours), individual work with students pertaining to their respective seminar paper (15 hours).
Student assessment and examination methods:	Seminar paper and oral examination.
Course assessment:	Doctoral committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

ZZT104 LINEAR INTEGRAL AND DISCRETE TRANSFORMATIONS	
Lecturer:	**Dr. Tomislav Marošević, Assistant Professor**
ECTS credits:	6 ECTS lecture attendance: 1.5 ECTS seminar paper: 3 ECTS oral examination: 1.5 ECTS
Knowledge and skills acquired:	Knowledge of theoretical foundation of linear integral transformations (Fourier, wavelet) and its applications in mathematics and other fields.
Course contents:	Fourier integral. Fourier and inverse Fourier transformations – basic properties. Fourier cosine and sine transformation. Discrete Fourier transformation. Fast Fourier transformation (FFT). Applications of (discrete) Fourier transformation (difference equations). Wavelet transformations (continuous and discrete); multiresolution analysis, mother wavelets. Other related transformations (Laplace, z-transformation).
Obligatory literature:	1. G. Bachman, L. Narici, E. Beckenstein: Fourier and Wavelet Analysis, Springer-Verlag, New York, 2000 2. W. L. Briggs, V. E. Henson, The DFT – An Owner's Manual for the Discrete Fourier Transform, SIAM, Philadelphia, 1995
Recommended additional literature:	1. C. Gasquet, C. Witomski, Fourier Analysis and Applications - Filtering, Numerical Computation, Wavelet, Springer-Verlag, New York, 1999 2. D. Ugrin-Šparac, Linearne integralne transformacije, Tehnička Enciklopedija, T.VII, p 514-524, Leksikografski zavod Zagreb
Prerequisites:	Materials of all mathematical courses taught at the undergraduate study programme in Electrical Engineering.
Teaching methods:	Lectures (30 hours), individual work with students pertaining to their respective seminar paper (15 hours).
Student assessment and examination methods:	Seminar paper and oral examination.
Course assessment:	Doctoral committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

ZZT105 TECHNICAL SYSTEMS MANAGEMENT	
Lecturer:	**Dr. Zlatko Lacković , Full Professor**
ECTS credits:	6 ECTS lecture attendance: 1.5 ECTS seminar paper: 3 ECTS oral examination: 1.5 ECTS
Knowledge and skills acquired:	Defining and recognising basic technical systems. Project design, maintenance and exploitation of technical systems.
Course contents:	Introduction to research work. Basic features and types of management. Technical systems and processes. Systematic approach to project conduction. Preliminary study, suitability study and investment programme. Project lifecycle. Principles of technical systems design. Project documentation. Consulting, construction and control. Exploitation and maintenance planning. Effectiveness and reliability of technical systems. Maintenance as a system and maintenance expenses. Reliability testing and exploitation expenses. Human resources management. Motivation of team members. Seminar paper on technical system design.
Obligatory literature:	1. B. Hodges, The Economic Management of Physical Assets, 2001 2. S. Nakajima, TPM Development Program, 1997 3. P. Willmott, TPM the Western Way, 2000
Recommended additional literature:	1. J. Mowbray, Reliability-Centred Maintenance, 2003 2. H. Biedermann, Ersatzteillogistik, 1996
Prerequisites:	
Teaching methods:	Lectures (30 hours), individual work with students pertaining to their respective seminar papers (15 hours).
Student assessment and examination methods:	Seminar paper and oral examination.
Course assessment:	Doctoral committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

ZZT106 DECISION MAKING THEORY	
Lecturer:	**Dr. Tihomir Hunjak, Full Professor**
ECTS credits:	6 ECTS lecture attendance: 1.5 ECTS seminar paper: 3 ECTS oral examination: 1.5 ECTS
Knowledge and skills acquired:	Introduction to and application of the decision making theory, use and development of information decision making systems.
Course contents:	Introduction; decision making, elements of decision making, methods for decision making. Multi-criteria decision making. Vector optimisation and an efficient solution. Basic theoretical results and characterisation of efficient solutions. Multi-criteria decision making issues – aims, criteria, criteria complexity. Value theory; postulates, functions. Usefulness theory. Analytic Hierarchy Process (AHP method) and Analytic Network Process (ANP method). Method of values for determining alternative priorities and criteria based on their pairwise comparison. Hierarchical decision making and AHP method. Criteria interaction modelling; reflexive relationship and network problem structure. ANP method. Method of values for determining alternative priorities and criteria based on their pairwise comparison and complex relations. Preference relations. Criterion and pseudocriterion. ELECTRA and PROMETHEE methods. Decision making methods under conditions of uncertainty and risks. Classical decision making theory, decision making tree, Bayes formula, information values. Risk and risk analysis based on Monte Carlo simulation. Risk analysis in project management. Modelling of uncertainty using fuzzy numbers and logic. Fuzzy variant of selected methods for multi-criteria decision making.
Obligatory literature:	1. Čaklović, L.: Teorija vrednovanja, Naklada Slap, Jastrebarsko, 2014 2. Figueira, J., Greco, S., Ehrgott, M., (eds): Multiple Criteria Decision Analysis: State of the Art Surveys, Springer Science + Business Media, Inc., New York, 2005 3. French, S.: Decision Theory, Ellis Harwood, Chichester, 1986 4. Saaty, T.L., Vargas, L.G., Decision Making with the Analytic Network Process, Springer Science + Business Media, LLC, New York, 2006
Recommended additional literature:	1. Robert T. Clemen: Making Hard Decisions: An Introduction to Decision Analysis, Duxbury Press; 2 edition, 1997 2. Saaty, T.L., Multicriteria Decision Making: The Analytic Hierarchy Process, RWS Publications, 4922 Ellsworth Ave., Pittsburgh, PA 15213. 3. Goodpasture, J.C., Quantitative Methods in Project Management, J. Ross Publishing, 2004 4. Schuyler, J., Risk and Decision Analysis in Projects, Project Management Institute, 2001 5. Sikavica, P., Hunjak, T., Begičević-Redep, N., Hernaus, T.: Poslovno odlučivanje, Školska knjiga, Zagreb, 2014
Prerequisites:	
Teaching methods:	Lectures (30 hours), individual work with students pertaining to their respective seminar papers (15 hours).
Student assessment and examination methods:	Seminar paper and oral examination.
Course assessment:	Doctoral committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

ZZT107 RESEARCH METHODS	
Lecturer:	**Dr. Snježana Rimac-Drlje, Full Professor**
ECTS credits:	6 ECTS lecture attendance: 0.5 ECTS seminar paper: 3 ECTS project proposal: 1.5 ECTS seminar paper presentation: 0.5 ECTS
Knowledge and skills acquired:	Individual planning and conducting scientific research aiming to acquire knowledge in a selected scientific area; writing and publishing a scientific paper; understanding rules for writing a project proposal
Course contents:	Classification of science. Categories of scientific research: fundamental, applied, developmental; examples. Research task and scientific hypothesis. Methods of research: inductive-deductive method, experimental method, measurement methods. Bibliographic and citation database (Web of Science, Current Contents, Journal Citation Reports, Scopus, Google Scholar); efficient database searching; procedures for finding journals and articles in a particular scientific area. Concept and choice of an article topic, basic elements of a scientific article and the process of its submission, reviews and publications in a journal. Presentation of a paper on scientific conferences. Ethics in carrying out research work. Copyright protection. Overview of the current funding programmes for projects financing. Preparing a project proposal. An example of good practice. Basics of project management.
Obligatory literature:	1. D.V. Thiel: Research Methods for Engineers, Cambridge University Press, 2014
Recommended additional literature:	1. M. Žugaj: Metodologija znanstveno-istraživačkog rada. Fakultet organizacije i informatike, Varaždin, 1997 2. R. Zelenika: Metodologija i tehnologija izrade znanstvenog i stručnog djela. Ekonomski fakultet, Rijeka, 2000
Prerequisites:	None
Teaching methods:	Lectures (30 hours), individual work with students pertaining to their respective seminar paper (15 hours).
Student assessment and examination methods:	Seminar paper and its presentation, drafting a project proposal.
Course assessment:	Doctoral committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

ZEUK23 EVOLUTIONARY ALGORITHMS AND APPLICATIONS	
Lecturer:	**Dr. Rudolf Scitovski, Full Professor**
ECTS credits:	6 ECTS lecture attendance: 1.5 ECTS seminar paper: 4.5 ECTS
Knowledge and skills acquired:	Knowledge of fundamental evolutionary algorithms and their applications in some research fields. Implementation of Mathematica and Matlab.
Course contents:	Examples. Convex and quasi-convex functions. Downhill methods for convex functions (coordinate relaxation, gradient method, Newton and quasi-Newton minimisation method). One-dimensional minimisation of quasi-convex functions (Bound method, Bisection method, Golden section method). One-dimensional global optimisation (Lipschitz continuous function, Pijavski method, Schubert method, DIRECT algorithm). Multidimensional global optimisation (DIRECT optimisation algorithm for a multi-variable function, DIRECT optimisation algorithm for a symmetrical function). Evolutionally algorithms. Nelder-Mead method.
Obligatory literature:	1 .R. Scitovski, K. Sabo, D. Grahovac, Globalna optimizacija, Odjel za matematiku, *Sveučilište u Osijeku,* 2016 – rukopis 2. E. M. T. Hendrix, B. G. Tóth, P. M. Pardalos, D. Z. Du *(Eds.),* Introduction to Nonlinear and Global Optimization *Springer,* 2010
Recommended additional literature:	1. R. Grbić, E.K. Nyarko, R. Scitovski, A modification of the DIRECT method for Lipschitz global optimization for a symmetric function, *Journal of Global Optimization, 57(*2013*),* 1193-1212 2. R. Paulavičius, J. Žilinskas, Simplicial Global Optimization, Springer, 2014 3. J. D. Pintér, Global Optimization in Action (Continuous and Lipschitz Optimization: Algorithms, Implementations and Applications), Kluwer Academic Publishers, Dordrecht, 1996 4. J. Pintér,*(Ed.)* Global Optimization: Scientific and Engineering Case Studies, Springer, 2006 5. Gablonsky, J. M.: Direct version 2.0, Technical report, Center for Research in Scientific Computation. North Carolina State University (2001) 6. R. Scitovski, N. Truhar, Z. Tomljanović, Metode optimizacije, *Odjel za matematiku, Sveučilište u Osijeku,* 2014 7. Y. D. Sergeyev, D. E. Kvasov, J. Cochran *(Ed.),* Lipschitz global optimization, Wiley Encyclopedia of Operations Research, 2011 8. C.M. Bishop, M. Jordan, J. Kleinberg, B. Scho¨lkopf *(Eds.),* Pattern Recognition and Machine Learning, Springer, 2006 9. N. Truhar, Numerička linearna algebra, *Odjel za matematiku, Sveučilište u Osijeku,* 2010
Prerequisites:	
Teaching methods:	Lectures (30 hours), individual work with students pertaining to their respective seminar papers (15 hours).
Student assessment and examination methods:	Evaluation of research competencies in writing a research paper.
Course assessment:	Doctoral committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

BRANCH POWER ENGINEERING

ZETE01 POWER SYSTEM OPTIMISATION	
Lecturer:	**Dr. Lajos Jozsa, Full Professor**
ECTS credits:	6 ECTS lecture attendance: 1.5 ECTS seminar paper: 3 ECTS oral examination: 1.5 ECTS
Knowledge and skills acquired:	Knowledge of modern optimisation models of power system operation, i.e. sufficient consumers' supply with electric energy of a defined quality by minimal costs for primary energy and environmental influence.
Course contents:	Basic optimisation aspects. Optimisation within the Energy Management System (EMS). Linear algebra basics. Unconstrained optimisation. Non-linear least square optimisation problems. Solution of an equality constrained non-linear optimisation problem. Mathematical optimisation problem formulation and optimality conditions. Well-defined constrained optimisation problems with straight-forward solution methods. Quadratic programming. Linear programming. Non-linear optimisation problems. Optimal power flow.
Obligatory literature:	1. Rainer Bacher: Netzleittechnik und Optimierung elektrischer Netze, Eidgenössische Technische Hochschule, Zürich, 2000
Recommended additional literature:	1. M. Plaper, Principi optimalnosti u mrežama za prijenos i distribuciju električne energije, Elektroinštitut "Milan Vidmar" Ljubljana, 1980 2. H. Edelmann, K. Theilsiefje: Optimaler Verbundbetrieb in der elektrischen Energieversorgung Springer Verlag Berlin – Heidelberg - New York 1974 3. J. Arrillaga, C.P. Arnold: Computer Analysis of Power Systems John Wiley & Sons Chichester / New York / Brisbane / Toronto / Singapore, 1995 4. E. Handschin: Elektrische Energieversorgungssysteme, Teil I, Teil II Hüthig Verlag Heidelberg, 1984
Prerequisites:	Power Networks, Power System Analysis, Power System Operation Control
Teaching methods:	Lectures (30 hours), individual work with students pertaining to their respective seminar papers (15 hours)
Student assessment and examination methods:	Seminar paper and oral examination.
Course assessment:	Doctoral committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

ZETE02 RELIABILITY AND AVAILABAILITY OF ELECTRIC POWER SYSTEM	
Lecturer:	**Dr. Srete Nikolovski, Full Professor**
ECTS credits:	6 ECTS lecture attendance: 1.5 ECTS seminar paper: 3 ECTS oral examination: 1.5 ECTS
Knowledge and skills acquired:	Application of the reliability theory in power systems, reliability method calculations and availability of electric power system. Application of COMREL and DigSilent.
Course contents:	Theory of reliability, definition and conceptual approach. Reliability indices, functions of reliability and availability. Types and causes of faults. Independent and dependent faults, faults with a common cause. Multiple faults in power facilities. Models of failure intensity function. Reliability component model with planned reparation. Reliability component model with disconnection after failure. Availability and unavailability functions of repairable components. Repair function. Reliability and availability of power systems. Reliability of serial, parallel and combined systems. Reliability and availability calculations methods. Markov state space models. Minimal paths and areas methods. Frequency and duration methods. Component's redundancy. Optimisation of redundancy by reliability approach. Reliability models of power system components (switches, cables, bus bars, transformers). Examples of reliability indices calculation (failure frequency, failure duration, failure probability, expected energy not supplied) using COMREL and DigSILENT software.
Obligatory literature:	1. S. Nikolovski, The basic of reliability analysis of power system, 1995 2. R. Billinton, R. N. Allan, Reliability evaluation of engineering system, Plenum press, 1992 3. Instructions for programme packages “COMREL” and "STAREL", “DIgSILENT”
Recommended additional literature:	1. R. Bilinton, R. N. Allan, Reliability assessment of a large electric power system ”Kluwer Press 1993 2. E. Balagurusamy, Reliability engineering, McGraw-Hill, New York, 2004
Prerequisites:	Power System Analysis
Teaching methods:	Lectures (30 hours), individual work with students pertaining to their respective seminar papers (15 hours).
Student assessment and examination methods:	Project and oral examination.
Course assessment:	Doctoral committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required

ZETE03 TRANSFORMERS MANAGEMENT	
Lecturer:	**Dr. Predrag Marić, Associate Professor**
ECTS credits:	6 ECTS lecture attendance: 1.5 ECTS seminar paper: 3 ECTS oral examination: 1.5 ECTS
Knowledge and skills acquired:	Knowledge of transformers management.
Course contents:	Power, distribution and instrument transformers. Selection of optimal characteristics of power and distribution transformers. Total owing costs. Selection of optimal solution: capitalised losses, cooling type, cooling control. Ordering (tender and contract). Quality assurance during manufacture of transformers (QA). Final tests: routine, type, and special. Transformer commissioning. Transformer operation. Transformer maintenance (control, inspection, testing, monitoring, refurbishment). Diagnostics of transformer condition (indirect and direct methods). Transformer upgrading (uprating, life extension). Transformer retirement (replacing).
Obligatory literature:	1. A. Dolenc, Transformers, Sveučilište u Zagrebu, 1968 (in Croatian) 2. V. Bego, Instrument Transformers, Školska knjiga, 1977 (in Croatian) 3. R. Wolf, Testing of electrical machines I, Sveučilište u Zagrebu, 1964 (in Croatian)
Recommended additional literature:	1. I. Bakija, QA according to ISO 9000, Privredni vjesnik/Zagrebačka banka, 1992 (in Croatian) 2. Dielectric diagnosis of electrical equipment for AC applications and its effects on insulation coordination, CIGRE, 1990 3. Generic guidelines for the life extension of plant electrical equipment, EPRI EL-5885, Project 2820-2, final report, July 1988
Prerequisites:	Fundamentals of Electrical Engineering, and Power, Distribution and Instruments Transformers.
Teaching methods:	Lectures (30 hours), individual work with students pertaining to their respective seminar papers (15 hours).
Student assessment and examination methods:	Seminar paper and oral examination.
Course assessment:	Doctoral committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

ZETE04 ADVANCED ELECTRICAL MATERIALS	
Lecturer:	**Dr. Tomislav Mrčela, Full Professor**
ECTS credits:	6 ECTS lecture attendance: 1.5 ECTS seminar paper: 3 ECTS oral examination: 1.5 ECTS
Knowledge and skills acquired:	Different types of advanced materials and structures.
Course contents:	Polymeric materials (thermosetting, thermoplastics, elastomers and rubbers, biopolymers, liquid crystal polymer). Composites (CMC, MMC, PMC). Engineering ceramics. Smart (intelligent) materials. Cellular solids and foams. Nano-materials and technology. Biomimetic materials.
Obligatory literature:	1. T. Filetin: Pregled razvoja i primjene suvremenih materijala, HDMT, Zagreb, 2000 2. T. Filetin: Izbor materijala pri razvoju proizvoda, Fakultet strojarstva i brodogradnje, Zagreb, 2000 3. W. D. Callister, Materials science and engineering: an introduction, John Wiley & Sons, New York, 2000 3. Keramički materijali – tehnička primjena, HDMT, Zagreb, 2004 4. D. Lukkassen and A. Meidell, Advanced Materials and Structures and their Fabrication Processes, Narvik University College, 2003
Recommended additional literature:	1. R. M. Brick et al., Structure and Properties of Engineering Materials, McGraw Hill, 1977 2. T. Filetin: Materijali i tehnologijski razvoj, Akademija tehničkih znanosti Hrvatske, Zagreb, 2002
Prerequisites:	Chemistry
Teaching methods:	Lectures (30 hours), individual work with students pertaining to their respective seminar papers (15 hours).
Student assessment and examination methods:	Seminar paper and oral examination.
Course assessment:	Doctoral committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

ZETE05 ELECTRICITY MARKET	
Lecturer:	**Dr. Mladen Zeljko, Assistant Professor**
ECTS credits:	6 ECTS lecture attendance: 1.5 ECTS seminar paper: 3 ECTS oral examination: 1.5 ECTS
Knowledge and skills acquired:	Knowledge of power market operation. Regulatory process and operating electrical power utilities in market conditions.
Course contents:	Restructuring of a power engineering sector. Competition in power system. Bilateral contracts. Power market fundamentals. Basics of auction mechanism. Regulation and deregulation. Day-ahead market designs. Pricing power energy and capacity. Planning purchase and sell electricity on an open electricity market. Power demand and supply. Competition on electricity market. Marginal costs on a power market. Reliability and investment policy. Reliability and generation. Operating-reserve prices. Market dynamics and the profit function. Market structure. Market architecture. Designing and testing market rules. Power market. Locational prices (power transmission, power distribution, losses). Physical transmission rights. Congestion pricing methods. Pricing losses on lines and at nodes.
Obligatory literature:	1. S. Stoft: Power System Economics: Designing Markets for Electricity, J. Wiley, 2002 2. G. Rothwell, T. Gomez: Electricity Economics: Regulation and Deregulation. J. Wiley, 2003
Recommended additional literature:	1. M. Shahidehpour, H. Yamin, Z. Li: Market operations in electric power systems: Forecasting, Scheduling, and Risk Management, J. Wiley, 2002
Prerequisites:	High Voltage Engineering, Electrical Switching Devices, Electrical Measurements I and II
Teaching methods:	Lectures (30 hours), individual work with students pertaining to their respective seminar papers (15 hours).
Student assessment and examination methods:	Seminar paper and oral examination.
Course assessment:	Doctoral committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

ZETE06 SWITCHGEAR AND HIGH VOLTAGE ENGINEERING	
Lecturer:	**Dr. Jože Pihler, Full Professor**
ECTS credits:	6 ECTS lecture attendance: 0.5 ECTS class participation: 0.5 ECTS seminar paper: 2 ECTS oral examination: 3 ECTS
Knowledge and skills acquired:	Basics of designing and testing switchgears. Conducting research and tests.
Course contents:	Contemporary design of switchgears; use of the current and development of new program tools for device design, selection of insulating and arcing media, research of switchgear influences to people and environment by normal and fault operation. Sources and types of high voltages on electrical devices operation. Sources and types of large currents on electrical devices operation. Types of high voltages and large currents which are necessary to consider when designing new electrical apparatus and devices. Devices for generation and measuring high voltages and large currents. Verifying of endurance of new electrical devices prototype: cooperation in research of a new product, defining and carrying out tests.
Obligatory literature:	
Recommended additional literature:	1. Stewart, Stan**:** *Distribution switchgear Electric switchgear*, Published by The Institution of Engineering and Technology, London, United Kingdom, 2008**,** ISBN 0 85296 107 3. 2. Steffen Rebennack, Mario V.F. Pereira, Niko A. Iliadis: *Handbook of Power Systems I*, © Springer-Verlag Berlin Heidelberg 2010, ISBN: 978-3-642-02492-4 e-ISBN: 978-3-642-02493-1. 3. Hugh M. Ryan: High Voltage Engineering and Testing, IET, ISBN -13: 978-1849192637, 2013 4. W. Hauschild, E. Lemke: High-Voltage Test and Measuring Techniques, Springer 2014 5. J. Voršič, J. Pihler: *Tehnika visokih napetosti in velikih tokov*, Univerza v Mariboru, Fakulteta za elektrotehniko, računalništvo in informatiko, Maribor, 2005 6. J. Pihler: *Stikalne naprave elektroenergetskega sistema*, Univerza v Mariboru, Fakulteta za elektrotehniko, računalništvo in informatiko, Maribor, 2003
Prerequisites:	
Teaching methods:	Lectures (30 hours), individual work with students pertaining to their respective seminar papers (15 hours).
Student assessment and examination methods:	Seminar paper and oral examination.
Course assessment:	Doctoral committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

ZEUE01 FAULT DETECTION IN AC ELECTRICAL MACHINES	
Lecturer:	**Dr. Željko Hederić, Associate Professor**
Collaborator:	**Dr. Miralem Hadžiselimović, Associate Professor**
ECTS credits:	6 ECTS lecture attendance: 1.5 ECTS seminar paper: 3 ECTS oral examination: 1.5 ECTS
Knowledge and skills acquired:	Knowledge about faults and detection methods in AC electrical machines.
Course contents:	Break of a squirrel-cage induction motor and determination of characteristic frequencies in stator current, axial leakage flux, shaft current and vibration. Coil short circuit in a stator winding and determination of characteristic frequencies in axial leakage flux and shaft currents. Eccentric rotor position in a stator hole and determination of characteristic frequencies in stator currents, axial leakage flux, shaft currents and vibration. Influence of induction machines power supply from an inverter to overvoltage, shaft and bearing currents.
Obligatory literature:	1. P. Vas, Parameter Estimation, Condition Monitoring and Diagnosis of Electrical Machines, Clarendon Press, Oxford, 1993 2. R. Richter, Elektrische Maschinen I, Basel/Stuttgart, Birkhäuser Verlag, 1967
Recommended additional literature:	
Prerequisites:	Electrical Machines I and II.
Teaching methods:	Lectures (30 hours), individual work with students pertaining to their respective seminar papers (15 hours).
Student assessment and examination methods:	Seminar paper and oral examination.
Course assessment:	Doctoral committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

ZEUE02 AUTOMATIC ELECTRIC DRIVES	
Lecturer:	**Dr. Željko Hederić, Associate Professor**
Collaborator:	**Dr. Bojan Štumberger, Associate Professor**
ECTS credits:	6 ECTS lecture attendance: 1.5 ECTS seminar paper: 3 ECTS oral examination: 1.5 ECTS
Knowledge and skills acquired:	Understanding the working principles of an automatic electric drive and its application in automated industrial processes.
Course contents:	Basic types of electric drives. Stationary and dynamic states. Four-quadrant drive. DC motor drives with variable voltage control. AC-DC and DC-DC converters. AC drives with variable frequency and voltage control. AC-AC inverters. Drive systems with binary control. Servo drives. Servo motors and stepping motors. Mechatronic system. High dynamic using motion control. Motion control applications. Automation of technical processes using bus systems for measure, control and drive technique connecting. Electric drives simulating the use of the software package MATLAB-Simulink and its tool part SimPowerSystems.
Obligatory literature:	1. Jurković, B.: Elektromotorni pogoni, 4. izdanje, Školska knjiga Zagreb, 1990 2. Group of authors: Elektromotorni pogoni, Tehnička enciklopedija, svezak 4, str. 417-442, JLZ Zagreb, 1973
Recommended additional literature:	1. Riefenstahl, U.: Elektrische Antriebstechnik, Teubner Verlag, Stuttgart Leipzig, 2000 2. Stölting, H.-D.; Kallenbach, E.: Handbuch Elektrische Klein-antriebe, Hanser Verlag, München Wien, 2001 3. Vogel, J.: Elektrische Antriebstechnik, 6. Auflage, Hütig Verlag Heidelberg, 1998
Prerequisites:	Electrical Machines, Electric Drives.
Teaching methods:	Lectures (30 hours), individual work with students pertaining to their respective seminar papers (15 hours).
Student assessment and examination methods:	Seminar paper and oral examination.
Course assessment:	Doctoral committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

ZEUE03 APPLICATIONS OF POWER ELECTRONIC SYSTEMS IN POWER ENGINEERING	
Lecturer:	**Dr. Denis Pelin, Associate Professor**
ECTS credits:	6 ECTS lecture attendance: 1.5 ECTS seminar paper: 3 ECTS oral examination: 1.5 ECTS
Knowledge and skills acquired:	Understanding the working principles of power electronic equipment used in power networks.
Course contents:	Influence of power electronic equipment on power networks. Apparent power components. Higher harmonics of voltage and current in three-phase networks. Mitigation methods. Instantaneous active and reactive power. Conditions for complete instantaneous compensation. Active filters. AC/DC converters for HVDC. AC/DC converter control techniques. AC filters. Static compensators. Thyristor controlled reactors. Thyristor switched condensers. Flexible AC transmission systems.
Obligatory literature:	1. Mohan, N. Undeland, T. M. Robbins, W. P. Power electronics, John Wiley & Sons Inc., 1995 2. Rashid, M. H. Power electronics, Pearson Prentice Hall, 2004 3. International Workshop on Power Definitions and Measurements under Non-Sinusoidal Conditions, Selected papers, European Transactions on Electrical Power Engineering, Vol. 3, No.1 1993, pp. 5-106.
Recommended additional literature:	
Prerequisites:	Power Electronics.
Teaching methods:	Lectures (30 hours), individual work with students pertaining to their respective seminar papers (15 hours).
Student assessment and examination methods:	Seminar paper and oral examination.
Course assessment:	Doctoral committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

ZEUE04 POWER SYSTEM STABILITY	
Lecturer:	**Dr. Predrag Marić, Associate Professor**
ECTS credits:	6 ECTS lecture attendance: 1.5 ECTS seminar paper: 3 ECTS oral examination: 1.5 ECTS
Knowledge and skills acquired:	Master of complex methodology of multi-machine power system analysis.
Course contents:	Mathematical system foundation in general. Controllability, observability and stability. Dynamic models of one-machine and multi-machine power systems in parameter space. Electromechanical rotor movement of synchronous generators during and after large disturbances. Power system transient stability. Linearised models of power systems and static stability (stability after minor disturbances). Coherence of rotor movement of synchronous generators in power systems and participatory factors. Devices for stability and damping enhancement. Electromechanical swing stabilisers.
Obligatory literature:	1. Edward W. Kimbark: Power System Stability, IEEE PRESS, New York 1995 2. Prabha Kundur: Power System Stability and Control, McGraw Hill, Inc., New York, 1994 3. Muharem Mehmedović: Identifikacija parametara sustava regulacije uzbude sinkronih strojeva, Doktorska disertacija, Elektrotehnički fakultet Sveučilišta u Zagrebu, Zagreb 1995
Recommended additional literature:	1. V. A. Vjenjikov: Perehodnie eljektromjehaničeskie procjesi v eljektričeskih sistjemah, Moskva, Vsšaja škola, 1970
Prerequisites:	AC Motors, Linear and Nonlinear Electrical Networks, Linear Algebra and Differential Equation, Some of Computer Languages, MATLAB.
Teaching methods:	Lectures (30 hours), individual work with students pertaining to their respective seminar papers (15 hours).
Student assessment and examination methods:	Seminar paper and oral examination.
Course assessment:	Doctoral committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

ZEUE05 DEVELOPMENT IN HIGH VOLTAGE SF6 GAS-INSULATED SUBSTATIONS-GIS	
Lecturer:	**Dr. Zoran Baus, Full Professor**
ECTS credits:	6 ECTS lecture attendance: 1.5 ECTS seminar paper: 3 ECTS oral examination: 1.5 ECTS
Knowledge and skills acquired :	Acquisition of elementary knowledge for design, maintenance and control of SF6 GIS.
Course contents:	Ionisation phenomena in SF6. Breakdown mechanisms in low divergence fields. Quasi-uniform fields (coaxial cylinders). Effects of surface roughness. Breakdown in GIS. Review of recent developments in SF6. Fundamental properties of SF6. Construction and service life of HV SF6 GIS: circuit breaker, current transformers, voltage transformers, disconnect switches, ground switches, bus, air connection, cable connections, direct transformer connections, surge arrester, control system, gas monitor system, gas compartments and zones, electrical and physical arrangement, grounding, testing, installation, operation and interlocks, maintenance. Economics of GIS. Possible improvements in SF6 insulation. Use of additives or gas mixtures. Impact of SF6 technology upon: a) transmission switchgear and b) distribution and utility switchgear. Partial discharge diagnostic techniques for GIS. Generation and transmission of UHF signals in GIS. Application of UHF technique to PD detection in GIS. Gas-Insulated Transmission Line (GIL).
Obligatory literature:	1. H. M. Ryan and G. R. Jones: SF6 Switchgear, 1988 2. John D. Mc. Donald: Electric Power Substations Engineering, CRC Press, 2003 3. M. Haddad and D. Warne: Advances in High Voltage Engineering.
Recommended additional literature:	1. B. Belin: Uvod u teoriju električnih sklopnih aparata, Školska knjiga-Zagreb, 1987
Prerequisites:	HV Engineering, Electrical Switching Devices, Electrical Measurements I and II
Teaching methods:	Lectures (30 hours), individual work with students pertaining to their respective seminar papers (15 hours).
Student assessment and examination methods:	Written examination
Course assessment:	Doctoral committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

ZEUE06 MONITORING AND POWER QUALITY	
Lecturer:	**Dr. Srete Nikolovski, Full Professor**
ECTS credits:	6 ECTS lecture attendance: 1.5 ECTS seminar paper: 3 ECTS oral examination: 1.5 ECTS
Knowledge and skills acquired :	Knowledge of methods, processes and devices for power quality monitoring and measuring.
Course contents:	Power quality indices and power quality monitoring. European EN 50160 and ANSI-IEEE 512 power quality norms. Voltage variations, long time (Plt) and short time (Pst) flickers, harmonics, interharmonics, ripple control, frequency, voltage asymmetric, dips and surges, transient overvoltages, load interruptions. Power quality monitoring and measuring. Continuous power quality monitoring. Stochastical cause of voltage dips. Voltage quality of HV, MV and LV networks and voltage quality analysers. Memobox 800, Topaz 1000, Wave Port 312. Harmonic network analysis and solutions for harmonic eliminations. Software for harmonic network analysis – SPECTRUM.
Obligatory literature:	1. Europska Norma EN 50160 prijevod 2000 2. Ž. Novinc: «Kakvoća električne energije» Graphis 2004 3. G. T. Heydt: Electric Power Quality. Stars in a Circle Publications, West La Fayette, Indiana, USA, 1991
Recommended additional literature:	1. R. Dugan et al.: *Electrical Power System Quality* , McGraw –Hill New York 1996 2. Instructions for MEMOBOX and TOPAS, QwavePower
Prerequisites:	Electrical Networks and Power System Analysis.
Teaching methods:	Lectures (30 hours), individual work with students pertaining to their respective seminar papers (15 hours).
Student assessment and examination methods:	Seminar paper and oral examination.
Course assessment:	Doctoral committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

ZEUE07 TRANSIENTS IN POWER SYSTEMS	
Lecturer:	**Dr. Marinko Stojkov, Full Professor**
ECTS credits:	6 ECTS lecture attendance: 1.5 ECTS seminar paper: 3 ECTS oral examination: 1.5 ECTS
Knowledge and skills acquired:	Knowledge of electromagnetic transients in power systems.
Course contents:	Temporary overvoltages due to ground junction, load loss and ferroresonance. Switching overvoltages on power line integration, fault occurrence, fault elimination, and disconnection of capacitance and inductive current. Atmospheric overvoltages. Calculation of overvoltages. Element modelling: overhead lines, cables, power and instrument transformers, surge arresters, high-voltage switchyards. Modern methods of overvoltage protection.
Obligatory literature:	1. P. Chowdhuri: Electromagnetic Transients in Power Systems, Research Studies Press, John Wiley & Sons Ltd, New York, 1996
Recommended additional literature:	1. L. van der Slus, Transients in Power Systems, John Wiley & Sons Ltd, New York, 2002 2. N. Watson, J. Arrilaga: Power Systems Electromagnetic Transients Simulation, IEE, 2003
Prerequisites:	Power Systems
Teaching methods:	Lectures (30 hours), individual work with students pertaining to their respective seminar papers (15 hours).
Student assessment and examination methods:	Seminar paper and oral examination.
Course assessment:	Doctoral Committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

ZEUE08 DISTRIBUTED GENERATION OF ELECTRICAL ENERGY FROM RENEWABLE SOURCES	
Lecturer:	**Dr. Damir Šljivac, Full Professor**
ECTS credits:	6 ECTS lecture attendance: 1.5 ECTS seminar paper: 3 ECTS oral examination: 1.5 ECTS
Knowledge and skills acquired:	Acquired knowledge in the field of direct transformation of renewable sources and their transformations to electrical energy.
Course contents:	Direct transformation of solar energy. Direct transformation of geothermal energy. Direct transformation of biomass. Direct transformation of biofuel and hydrogen. Energy balance of hydro energy. Energy balance of solar energy. Energy balance of wind energy. Energy balance of geothermal energy. Transformation of biofuel energy. Generation costs and operational costs of biomass, hydro energy, solar energy, wind energy, geothermal energy and biofuel for production of electrical energy. Transformations of biomass, hydro energy, solar energy, wind energy, geothermal energy and biofuel in electrical energy. Power and economical appraisal of installing renewable energy sources.
Obligatory literature:	1. B. Udovičić: Elektroenergetika, Školska knjiga, Zagreb, 1983 2. B. Udovičić: Energija i izvori energije, Građevinska knjiga, Beograd, 1988 3. V. Knapp, P. Kulišić: Novi izvori energije, Školska knjiga, Zagreb, 1984
Recommended additional literature:	1. B. Udovičić: Energetske pretvorbe i bilance, Građevinska knjiga, Beograd, 1988 2. B. Udovičić: Energetika i okoliš u globalizaciji, vlastita naklada, Zagreb, 2002 3. B. Udovičić: Neodrživost održivog razvoja, Kigen, Zagreb, 2004
Prerequisites:	
Teaching methods:	Lectures (30 hours), individual work with students pertaining to their respective seminar papers (15 hours).
Student assessment and examination methods:	Seminar paper and oral examination.
Course assessment:	Doctoral Committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

ZEUE09 DYNAMICS OF ELECTRICAL MACHINES	
Lecturer:	**Dr. Željko Hederić, Associate Professor**
Course collaborator:	**Dr. Gorislav Erceg, Full Professor**
ECTS credits:	6 ECTS lecture attendance: 1.5 ECTS seminar paper: 3 ECTS oral examination: 1.5 ECTS
Knowledge and skills acquired:	Knowledge of mathematical models of different types of electrical machines and simulation and analysis of their dynamic characteristics.
Course contents:	General form of electrical machine equations. Coordinate transformation. Mathematical models of electrical machines. Analysis of DC machine dynamic characteristics. Transient phenomena analysis of induction and synchronous machines assuming constant speed. Simulation of induction and synchronous machines, various modes of operation, saturation. Analysis of nonlinear dynamic modes of operation. Small-displacement analysis of electrical machines: eigenvalues, transfer function formulation, stability, approximate analytic solutions.
Obligatory literature:	1. M. Jadrić, B. Frančić, Dinamika električnih strojeva, Graphis, Zagreb, 1997
Recommended additional literature:	1. P.C. Krause, Analysis of Electrical Machinery, McGraw-Hill, 1986
Prerequisites:	Mathematical Analysis, Matrix Algebra, Laplace transformation, Fundamentals of Electrical Engineering, Electrical Machines
Teaching methods:	Lectures (30 hours), individual work with students pertaining to their respective seminar papers (15 hours).
Student assessment and examination methods:	Seminar paper and oral examination.
Course assessment:	Doctoral Committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

ZEUE10 COMPLETE MEASUREMENT RESULT AND DECISION MAKING	
Lecturer:	**Dr. Kruno Miličević, Associate Professor**
ECTS credits:	6 ECTS lecture attendance: 1.5 ECTS seminar paper: 3 ECTS oral examination: 1.5 ECTS
Knowledge and skills acquired:	Introduction to the concepts of measurement uniformity, traceability of measurement results, measurement uncertainty, and ways of expressing measurement results. Interpretation of instrument specifications, how to choose the best instrument for a specific purpose, how to measure correctly, how to estimate measurement uncertainty, and how to make a decision on the basis of a complete measurement result.
Course contents:	Measurement result and measurement uncertainty. The correct expression of measurement results. Correct rounding of measurement results. Interpretation of instrument specifications. Estimation of measurement uncertainty. Testing. Evaluation of compliance and non-compliance with specifications. Decision making on the basis of a complete measurement result
Obligatory literature:	1. Z. Godec, Iskazivanje mjernog rezultata, Graphis, Zagreb, 1995 2. Guide to the expression of uncertainty in measurement, ISBN 92-67-10188-9, ISO, 1993
Recommended additional literature:	1. Weise, K., Wöger, W.: Messunsicherheit und Messdatenauswertung, Wiley VCH Verlag, ISBN 3-527-29610-7
Prerequisites:	Mathematics (derivation and statistics), Fundamentals of Electrical Engineering
Teaching methods:	Lectures (30 hours), individual work with students pertaining to their respective seminar papers (15 hours).
Student assessment and examination methods:	Seminar paper and oral examination.
Course assessment:	Doctoral Committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

ZEUE11 POWER SYSTEM PLANNING IN OPEN ELECTRICITY MARKET CONDITIONS	
Lecturer:	**Dr. Damir Šljivac, Full Professor**
ECTS credits:	6 ECTS lecture attendance: 1.5 ECTS seminar paper: 3 ECTS oral examination: 1.5 ECTS
Knowledge and skills acquired:	Knowledge of methods and models of power system planning in the open electricity market conditions taking into account economical risk assessment with respect to individual risk factors: potential market forecasting (load demand growth), pricing of energy sources and electrical energy, development of new technologies, the influence of hydrology, additional requests for environmental protection, legislative changes
Course contents:	Basic principles of power system planning. Planning time horizons. Assessment of a potential market. Modelling the operation of different types of power plants (forecasting the load curve and the load duration curve, conventional thermal power plants, combined heat and power (CHP) plants, hydroelectric and storage hydroelectric power plants, unconventional power plants). Planning models and techniques (simulation, optimisation). The logic of engaging power plants in market conditions. The difference between central power system planning and power system planning in market conditions. Electric energy generation costs for different types of power plants (constant and variable costs, marginal costs). Generation restrictions considering ecology demands (emission). Treatment of generation of new renewable sources (RES). Incentives to promote RES and possible deviations of the real open market (feed-in-tariff). Business interest of a company in electricity generation with respect to broader social and global interests (local vs. global optimum; the "more from less" principle; effects on the environment). The minimum cost vs. maximum profit principle. Risk factor analysis. Risk hedging. Operational planning of power plants (hourly, daily, weekly, yearly).
Obligatory literature:	1. B. Udovičić: Elektroenergetika, Kigen, Zagreb, 2005 2. H. Požar: Snaga i energija u elektroenergetskim sistemima, Prvi i drugi svezak, Informator, Zagreb, 2005
Recommended additional literature:	1. X. Wang, J. R. McDonald: Modern Power System Planning, McGraw-Hill Book, Company Europe, England, 1994 2. S. Stoft: Power System Economics, IEEE/Wiley, 2002 3. D. Feretić, Ž. Tomšić, D. Škanata, N. Čavlina, D. Subašić: Elektrane i okoliš, Element, Zagreb, 2000
Prerequisites:	Power system analysis, power system operation, power plants and their power engineering and economic characteristics, fundamental concepts of engineering economics, fundamental concepts of the electricity market, energy exchanges.
Teaching methods:	Lectures (30 hours), individual work with students pertaining to their respective seminar papers (15 hours).
Student assessment and examination methods:	Seminar paper and oral examination.
Course assessment:	Doctoral Committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

ZEUE13 NON-LINEAR ELECTRICAL NETWORKS AND DETERMINISTIC CHAOS	
Lecturer:	**Dr. Kruno Miličević, Associate Professor**
ECTS credits:	6 ECTS lecture attendance: 0.75 ECTS class attendance: 0.5 ECTS seminar paper: 2 ECTS oral exam: 2.75 ECTS
Knowledge and skills acquired:	Understanding complex behaviour of relatively simple non-linear electrical networks and their analyses
Course contents:	Analysis and measurement of non-linear electrical networks behaviour and the application to real-life examples of electrical networks such as circuits supplying non-linear loads, non-linear parts of power networks, etc. Modelling of non-linear electrical networks, measurement methods of parameters and effects of non-linear electrical networks, local and global behaviour of non-linear electrical networks, effects of initial values, types of steady states, deterministic chaos, use of chaos in communications
Obligatory literature:	1. Kapitaniak, Tomasz. Chaos for Engineers: Theory, Applications, and Control. New York, Springer Verlag, 2000. ISBN: 9783540665748
Recommended additional literature:	1. Strogatz, Steven H. Nonlinear Dynamics and Chaos: With Applications to Physics, Biology, Chemistry and Engineering. New York, NY: Perseus Books, 2001. ISBN: 9780738204536
Prerequisites:	
Teaching methods:	Lectures (30 hours), individual work with students pertaining to their respective seminar paper (15 hours).
Student assessment and examination methods:	Seminar paper and oral exam
Course assessment:	Doctoral committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

ZEUE14 SMART POWER GRIDS	
Lecturer:	**Dr. Zvonimir Klaić, Assistant Professor**
ECTS credits:	6 ECTS lecture attendance: 1.5 ECTS seminar paper: 2 ECTS oral examination: 2.5 ECTS
Knowledge and skills acquired:	Knowledge of the concept and application of smart grids and the possibilities of balancing supply and demand (consumption) in real time due to the impact of distributed generation (renewable energy sources) on conditions in the power system
Course contents:	Smart measurements and applications. The concept and design of smart grids and microgrids. Microgrid management and operation. Energy management. Integration of RES into smart grids. The benefits of smart grids and microgrids in relation to conventional networks. Optimisation methods in smart grids and microgrids.
Obligatory literature:	1. N. Hadziargyriou: Microgrids, Arhitectures and Control, IEEE Press, Wiley, 2014
Recommended additional literature:	1. Understanding Power Quality Problems, Math H.J. Bollen, IEEE Press, Wiley, 2000 2. L. Jozsa: Tokovi snaga u mreži, ETF Osijek, 2009 3. HRN EN 50160:2012, Naponske karakteristike električne energije iz javnog distribucijskog sustava
Prerequisites:	
Teaching methods:	Lectures (30 hours), individual work with students pertaining to their respective seminar papers (15 hours).
Student assessment and examination methods:	Seminar paper and oral examination.
Course assessment:	Doctoral Committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

ZEUE15 MODELLING AND CONTROL OF RENEWABLE ENERGY POWER PLANTS	
Lecturer:	**Dr. Danijel Topić, Assistant Professor**
ECTS credits:	6 ECTS lecture attendance: 1 ECTS research: 2 ECTS seminar paper: 2 ECTS oral examination: 1 ECTS
Knowledge and skills acquired:	Knowledge of modelling and control of renewable energy power plants. Application of mathematical and computer models of renewable energy power plants.
Course contents:	Basic characteristics of renewable energy power plants. Modelling of wind power plants. Modelling of photovoltaic systems. Modelling of small hydroelectric power plants. Modelling of geothermal power plants and biomass power plants. Modelling of the energy storage system. Modelling and simulation of distributed generation from renewable energy sources in the power system.
Obligatory literature:	1. Modeling and Control of Sustainable Power Systems, L. Wang (Ed.), Springer-Verlag Berlin Heidelberg, 2012 2. Vepa, Ranjan: Dynamic Modeling, Simulation and Control of Energy Generation, Springer, London, 2013
Recommended additional literature:	1. Olimpo Anaya-Lara, Nick Jenkins, Janaka Ekanayake, Phill Cartwright, Mike Hughes: Wind Energy Generation: Modelling and Control, John Wiley and Sons Ltd., Chichester, 2009 2. Ali Keyhani: Design of Smart Power Grid Renewable Energy Systems, John Wiley and Sons Inc., Hoboken, 2011 3. Renewable Energy Integration: Practical Management of Variability, Uncertainty and Flexibility in Power Grids, L.E. Jones (Ed.), Academic Press, 2014
Prerequisites:	
Teaching methods:	Lectures (30 hours), individual work with students pertaining to their respective seminar papers (15 hours).
Student assessment and examination methods:	Seminar paper and oral examination.
Course assessment:	Doctoral Committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

BRANCH COMMUNICATIONS AND INFORMATICS

ZETK01 CMOS APPLICATION SPECIFIC INTEGRATED CIRCUITS - ASIC	
Lecturer:	**Dr. Tomislav Švedek, Full Professor**
ECTS credits:	6 ECTS lecture attendance: 1.5 ECTS seminar paper: 3 ECTS oral examination: 1.5 ECTS
Knowledge and skills acquired:	Adopting modern microelectronic design and testing technologies, and building testability into application specific integrated circuits.
Course contents:	What is an application specific circuit – ASIC? When, why and how to use ASIC. Fabrication technology of standard and application specific integrated CMOS circuits. Challenges and foreseeable development of microelectronics in future generations of CMOS circuits. Design techniques of CMOS application specific integrated circuits: PLD, GA, StC, FC and SoC (System on Chip). Analogue and analogue/digital CMOS ASICs. An overview of Design for Testability (DFT) principles: ASIC I/Os MUX/DEMUX, scanning of memory elements, built-in self-testing. Application of DFT principles and evaluation of their applicability to digital circuits of medium, large and very large scale integration (hardware overhead against testability increase).
Obligatory literature:	1. T. Švedek, Osnove mikroelektronike, Elektrotehnički fakultet Osijek, 2002 2. S.L. Hurst, VLSI testing: digital and mixed analogue/digital techniques, IEE Circuit, Devices And Systems Series, London, 1996 Custom VLSI Microelectronics, Prentice-Hall, 1990 3. P. Biljanović, Mikroelektronika - Integrirani elektronički sklopovi, Školska knjiga, Zagreb, 1983
Recommended additional literature:	1. A. Sedra, K. Smith, Microelectronic circuits - 3rd ed., Saunders College Publishing, 1991 2. S.L. Hurst, Custom VLSI Microelectronics, Prentice-Hall, 1990
Prerequisites:	Electronics-related courses, Microelectronics
Teaching methods:	Lectures (30 hours), individual work with students pertaining to their respective seminar papers (15 hours).
Student assessment and examination methods:	Seminar paper and oral examination.
Course assessment:	Doctoral Committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

ZETK03 ANALYSIS AND SYNTHESIS OF COMMUNICATION PROTOCOLS	
Lecturer:	**Dr. Drago Žagar, Full Professor**
ECTS credits:	6 ECTS lecture attendance: 1.5 ECTS seminar paper: 3 ECTS oral examination: 1.5 ECTS
Knowledge and skills acquired:	Knowledge of all phases of communication protocol development, communication protocol specification, verification and testing methods. Knowledge and skills necessary for independent research in the field of communication protocols.
Course contents:	Protocols as languages. Protocol standardisation. Protocol components. Services and protocol environment. Procedural rules. Protocol design rules. Communication errors. Flow control, the window concept. Protocol specification and modelling. Processes, channels and variables. Verification models. Variables and types of data. Modelling of temporal functions. Types of errors by protocols. Service specification and protocol design. Protocol vocabulary and procedural rules. Finite state machines. Combined machines, extended finite state machines. Structural testing and verification. The execution of the I/O sequence. Alternative methods. Manual methods for protocol checking. Automated methods for protocol checking. The supertrace algorithm. Detection of various errors. Protocol simulators.
Obligatory literature:	1. Gerard J. Holzmann: Design and Validation of Computer Protocols, Prentice Hall, New Jersey, 1991 2. W. Stallings, Data and Computer Communications, MacMillan Publishing, New York, 2002
Recommended additional literature:	
Prerequisites:	
Teaching methods:	Lectures (30 hours), individual work with students pertaining to their respective seminar papers (15 hours).
Student assessment and examination methods	Seminar paper and oral examination.
Course assessment:	Doctoral Committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

ZETK04 OBJECT-ORIENTED PROGRAMMING	
Lecturer:	**Dr. Alfonzo Baumgartner, Assistant Professor**
ECTS credits:	6 ECTS lecture attendance: 1.5 ECTS seminar paper: 3 ECTS oral examination: 1.5 ECTS
Knowledge and skills acquired:	Knowledge of advanced approaches and solutions to object-oriented programming and development of software support.
Course contents:	Software production – a management view. Programming with symbolic and natural languages. Objects in open systems and object-oriented paradigm. Objects and artificial intelligence. Objects, components and transactions. Security. Instance management algorithms. Objects and agents. Synchronous and asynchronous components. Interoperability. Portability and interoperability. The battle for the middle tier and objects. Interfaces. Algebraic representation of specification language. Internal structure of object classes. Development of restriction-oriented objects. Methods. Object-oriented systems: design, debugging, packaging and documentation. Protocol, objects, threads, inheritance, syntax. Quantum, phase-oriented, page organised objects. Holo objects. OOP as a dynamic holostructure.
Obligatory literature:	1. Jović, F.: Process Control Systems, Chapman and Hall, London, Van Nostrand Reinhold Inc., New York, 1992 2. Sessions, R.: COM+ and the Battle for the Middle Tier, Wiley Computer Publishing, John Wiley & Sons Inc., New York, 2000 3. Kafura, J.: Object Oriented Software Design and construction with Java, Prentice Hall, 2000 4. Lamber, D.: The Future of Software, The MIT Press, Cambridge, Massachusetts, 2000
Recommended additional literature:	1. DeLoach, Scott A.: A Theory-Based Representation for Object-Oriented Domain Models, IEEE Trans. on Software Engineering, Vol.26, No.6, June 2000, 500-517. 2. Bolognesi, T.: Toward Constraint-Object Oriented Development, IEEE Trans. on Software Engineering, Vol.26, No.7, July 2000, 594-616. 3. http://www.tcm.phy.cam.ac.uk 4. http://java.sun.com/docs/books/tutorial/index/html
Prerequisites:	
Teaching methods:	Lectures (30 hours), individual work with students pertaining to their respective seminar papers (15 hours).
Student assessment and examination methods:	Seminar paper and oral examination. Publication of a conference paper.
Course assessment:	Doctoral Committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

ZETK06 RESOURCE AND PERFORMANCE MANAGEMENT IN COMPUTER SYSTEMS	
Lecturer:	**Dr. Goran Martinović, Full Professor**
ECTS credits:	6 ECTS lecture attendance: 1.5 ECTS seminar paper: 3 ECTS oral examination: 1.5 ECTS
Knowledge and skills acquired:	Basic concepts of scheduling problems and their implementation in resource management procedures. Models and tools for computer systems performance evaluation.
Course contents:	Principles of resource management in computer systems. Scheduling problems: types and complexity of algorithms, scheduling on single processor and parallel processors, deterministic and stochastic approaches. Communication delays and multiprocessor tasks. Resource constraints. Multicriteria scheduling. Scheduling in distributed systems. Influence of resource management, modelling and implementation on computer system performance. Real-time requirements. Autonomic systems. Performance evaluation: basics, measurement techniques. Workload. Capacity planning. Performance estimation. Data analysis. Comparing alternatives. Statistical models, basic queuing theory, stochastic and hybrid models. Performance prediction: regression, time series, pattern analysis. Software tools for measurement, evaluation and monitoring of performance. Real systems analysis on the level of architecture, operating system and applications.
Obligatory literature:	1. J. Blazewicz, K.H. Ecker, E. Pesch, G. Schmidt, J. Weglarz, Scheduling Computer and Manufacturing Processes, Springer, Berlin, 2001 2. C.S. Ram Murthy, G. Manimaran, Resource Management in Real-Time Systems and Networks, MIT Press, Cambridge, 2001 3. D.J. Lilja, Measuring Computer Performance: A Practitioner's Guide, Cambridge University Press, Cambridge, MA, 2000 4. D.A. Menasce, L.W. Dowdy, V.A.F. Almeida, Performance by Design : Computer Capacity Planning By Example, Prentice Hall, New York, NY, 2004 5. Lecturer's web pages.
Recommended additional literature:	1. C.U. Smith, L.G. Williams, C. Smith, L. Williams, Performance Solutions: A Practical Guide to Creating Responsive, Scalable Software (First edition), Addison-Wesley, Boston, MA, 2001 2. P. Fortier, H. Michel, Computer Systems Performance Evaluation and Prediction, Digital Press, New York, 2002 3. R.K. Jain, The Art of Computer Systems Performance Analysis: Techniques for Experimental Design, Measurement, Simulation, and Modelling, John Wiley & Sons, Indianapolis, IN, 1991
Prerequisites:	Fundamentals of Statistical Analysis, Real-time Computer systems.
Teaching methods:	Lectures (30 hours), individual work with students pertaining to their respective seminar papers (15 hours).
Student assessment and examination methods:	Seminar paper and oral examination.
Course assessment:	Doctoral Committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

ZETK07 ALGORITHMS AND GRAPHS	
Lecturer:	**Dr. Karlo Emannuel Nyarko, Assistant Professor** **Dr. Ratko Grbić, Assistant Professor**
ECTS credits:	6 ECTS lecture attendance: 1.5 ECTS seminar paper: 3 ECTS oral examination: 1.5 ECTS
Knowledge and skills acquired:	Linking earlier knowledge of graphs and algorithms and using graphs and relevant algorithms in engineering disciplines.
Course contents:	Algorithms and their complexity. Generic programming. Elementary and abstract data structures. Algorithms with characters and strings, searching algorithms for substrings. Introduction to cryptography. Algorithms and graphs: shortest path, minimum spanning tree, maximal flow. Bipartite graphs: assignment and matching problem. Solving network equations.
Obligatory literature:	1. Robert Sedgewick: Algorithms in C++, Addison-Wesley, 1992 2. Alan Dolan, Joan Aldous:Networks and Algorithms, John Wiley & Sons, 1993
Recommended additional literature:	1. Mark Allen Weiss: Data Structures and Algorithm Analysis in C, Addison Wesley, 1997
Prerequisites:	Fundamentals of algorithms and data structures including trees and graphs.
Teaching methods:	Lectures (30 hours), individual work with students pertaining to their respective seminar papers (15 hours).
Student assessment and examination methods:	Seminar paper and oral examination.
Course assessment:	Doctoral Committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

ZETK08 FAST ALGORITHMS FOR NP-HARD PROBLEMS	
Lecturer:	**Dr. Tomislav Rudec, Assistant Professor**
ECTS credits:	6 ECTS lecture attendance: 1 ECTS revision exams: 1 ECTS seminar paper: 1 ECTS oral examination: 3 ECTS
Knowledge and skills acquired:	Knowledge of approximation algorithms for NP-hard problems and the use of heuristic algorithms for problems with no polynomially fast solutions
Course contents:	NP-hard and NP-complete problems. NP-hard graph problems. NP-hard scheduling problems. Randomisation. On-line algorithms. The paging problem. Analysis and comparison of algorithms for the paging problem. The k-server problem. The optimal offline algorithm for the k-server problem. Fast approximation algorithms for the k-server problem.
Obligatory literature:	1. Allan Borodin Ran El-Yaniv. Online computation and competitive analysis. Cambridge University Press. 2005 2. D.S. Hochbaum (Ed.): Approximation Algorithms for NP-Hard Problems. PWS Publishing Company, Boston MA, 1997
Recommended additional literature:	1. C.H. Papadimitrou, K. Steiglitz: Combinatorial Optimization - Algorithms and Complexity, Second Edition. Prentice-Hall, Englewood Cliffs NJ, 1998
Prerequisites:	
Teaching methods:	Lectures (30 hours), individual work with students pertaining to their respective seminar papers (15 hours).
Student assessment and examination methods:	Seminar paper, revision exams and oral examination.
Course assessment:	Doctoral Committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

ZEUK01 INTERNET TECHNOLOGY	
Lecturer:	**Dr. Drago Žagar, Full Professor**
ECTS credits:	6 ECTS lecture attendance: 1.5 ECTS seminar paper: 3 ECTS oral examination: 1.5 ECTS
Knowledge and skills acquired:	Knowing advanced Internet technologies and research trends in this field, independent research.
Course contents:	The protocol hierarchy and reference models. A comparison and critical analysis of OSI and TCP/IP reference models. Advanced mechanisms for flow control and error detection. Routing algorithms. Routing protocols. Advanced mechanisms for congestion control. Interconnection in the Internet network – network layer and IP protocol. Transition from IPv4 to IPv6. Mobile IP. Mobile IP networks – mobile Internet. Basic and advanced components of transport protocols. Network management. Network control and management protocols: ICMP, SGMP, SNMP. Mobile agents in the Internet. Services in the Internet. Communication between the applications using XML. SOAP protocol. DNS service. Advanced media streaming technologies. Voice over Internet Protocol (VoIP). Multimedia services on demand, video on demand. Web design. Web structuring, XML and XSL. Quality of service in the Internet. The future of the Internet network and forthcoming technologies
Obligatory literature:	1. A. S. Tanenbaum, Computer Networks, Fourth Edition, Prentice-Hall PTR, Upper Saddle River, N. J., 2003 2. A. Bažant et al., Osnovne arhitekture mreža, Element, Zagreb, 2003 3. W. Stallings, Data and Computer Communications, MacMillan Publishing, New York, 2002
Recommended additional literature:	1. D. G. Messerschmitt, Networked Applications, Morgan Kaufmann, San Francisco, California, 1999
Prerequisites:	
Teaching methods:	Lectures (30 hours), individual work with students pertaining to their respective seminar papers (15 hours).
Student assessment and examination methods:	Seminar paper and oral examination.
Course assessment:	Doctoral Committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

ZEUK02 ANTENNA ARRAYS ANALYSIS	
Lecturer:	**Dr. Slavko Rupčić, Associate Professor**
ECTS credits:	6 ECTS lecture attendance: 1.5 ECTS seminar paper: 3 ECTS oral examination: 1.5 ECTS
Knowledge and skills acquired:	Fundamental knowledge of analysis and synthesis of antenna arrays, use of the MoM procedure for array radiation problems.
Course contents:	Basic EM sources. EM wave propagation. Regular linear antenna arrays. Irregular linear antenna arrays. High-directed arrays. Automatic phase tuning. Moving mean beam arrays. Simultaneous pattern arrays. Adaptive antenna systems. Analysis of planar, cylindrical and spherical arrays using the moment method approach (MoM).
Obligatory literature:	1. E. Zentner: Radiokomunikacije, Školska knjiga, Zagreb, 1980 2. Z. Haznadar: Elektromagnetska teorija i polja, Liber, Zagreb, 1972 3. E.C. Jordan, K.G.Balmain: Electromagnetic waves and radiating systems, Prentice-Hall, Inc. Englewood Cliffs, N.J, 1968 4. R.F. Harington: Field Computation By Moment Methods, Cazenovia, N.Y., 1987 5. J. Kraus, Electromagnetics, McGraw Hill, N.Y. 1984
Recommended additional literature:	1. R.F. Harrington, Time-harmonic electromagnetic fields, McGraw-Hill, New York, 1961
Prerequisites:	Maxwell's equations, EM wave propagation, analysis of simple antennas, one programming language (FORTRAN recommended).
Teaching methods:	Lectures (30 hours), individual work with students pertaining to their respective seminar papers (15 hours).
Student assessment and examination methods:	Seminar paper and oral examination.
Course assessment:	Doctoral Committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

ZEUK03 NOISE IN RADIOCOMMUNICATIONS	
Lecturer:	**Dr. Slavko Rupčić, Associate Professor**
ECTS credits:	6 ECTS lecture attendance: 1.5 ECTS seminar paper: 3 ECTS oral examination: 1.5 ECTS
Knowledge and skills acquired:	Knowledge of the characteristics of noise sources in communication systems and the application of modern noise measurement methods.
Course contents:	Statistical properties of noise. Probability theory application to noise analysis. The spectral density function and the autocorrelation function. Thermic noise, shot noise, 1/f noise. Noise in diodes, FET transistors, photodiodes and phototransistors. Noise in analysing tubes. Noise in television, signal-to-noise ratio, noise reduction in TV cameras. Noise generators, application and design. Measurements of the signal-to-noise ratio, noise factor, intermodulation noise and phase noise. Measurement of noise in television and mobile communications
Obligatory literature:	1. B. Zovko-Cihlar: Šum u radiokomunikacijama, Školska knjiga, 1987 2. M.S. Gupta: Electrical Noise: Fundamentals and Sources, IEEE Press, New York, 1987 3. A. Van Der Ziel: Noise: Sources, Characterization, Measurement, Prentice Hall, 1980
Recommended additional literature:	
Prerequisites:	Communication Systems, Probability and Statistics.
Teaching methods:	Lectures (30 hours), individual work with students pertaining to their respective seminar papers (15 hours).
Student assessment and examination methods:	Seminar paper and oral examination.
Course assessment:	Doctoral Committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

ZEUK04 INFORMATION TECHNOLOGY AND ENTREPRENEURSHIP	
Lecturer:	**Dr. Vlado Majstorović, Full Professor**
ECTS credits:	6 ECTS lecture attendance: 1.5 ECTS seminar paper: 3 ECTS oral examination: 1.5 ECTS
Knowledge and skills acquired:	Knowledge of basic aspects of information technology from the point of creation, development and business opportunities in the world of globalisation with special emphasis placed on its possibilities and application in the field of entrepreneurship.
Course contents:	Introduction. The concept and importance of information technology. Information technology trends. Information technology and business operations. Information technology architecture. Information system in business. Information technology and entrepreneurship. The role and importance of entrepreneurship. The area of entrepreneur activities. New entrepreneur possibilities and preparations for electronic business operations. Planning and starting electronic business. The Internet as a new channel of entrepreneur product distribution. Entrepreneur activities in the world of electronic business. Market and information about the market before any entrepreneurial undertaking. Market activities of entrepreneurs. Entrepreneurship and ethics.
Obligatory literature:	1. V. Čerić, M. Verga, Informacijska tehnologija u poslovanju, Element, Zagreb, 2004 2. Ž. Panian, Internet i malo poduzetništvo, Informator, Zagreb, 2000 3. J. Deželjin et al., Poduzetnički menadžment, M.E.P. Consult, Zagreb, 2002 4. J. Mishra, A. Mohatny, Design of Information Systems-a Modern Approach, Alpha Science, Bhabenswar, 2000
Recommended additional literature:	1. M. L. Tushman, P. Anderson, Managing Strategic Innovation and Change, Oxford University Press, 1977 2. V. Srića, J. Müller, Put k električkom poslovanju, Sinergija, Zagreb, 2001 3. G. Courtis, D. Cobham, Business Information Systems – Analysis, Design and Practice, Prentice Hall, Harlow, 2002
Prerequisites:	Fundamentals of computer engineering, management and entrepreneurship
Teaching methods:	Lectures (30 hours), individual work with students pertaining to their respective seminar papers (15 hours).
Student assessment and examination methods:	Seminar paper and oral examination.
Course assessment:	Doctoral Committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

ZEUK05 MODERN COMPUTER ARCHITECTURE	
Lecturer:	**Dr. Željko Hocenski, Full Professor**
ECTS credits:	6 ECTS lecture attendance: 1.5 ECTS seminar paper: 3 ECTS oral examination: 1.5 ECTS
Knowledge and skills acquired:	Students acquire knowledge of modern computer architecture in order to be able to solve certain problems on the available architecture as well as to compare advantages and shortcomings of particular modern computer system architectures.
Course contents:	Computer system. Reduced instruction set computers. Instructions. Instruction sets - CISC vs. RISC. Central processing unit. Register machine. Data types. Addressing modes. Pipelined processors. Hazards. Branching prediction. Scalar and superscalar processors. Out-of-order instruction issue. Out of-order instruction completion. Handling exceptions. Memory system acceleration. Cache memory. Virtual memory system. Computer system.
Obligatory literature:	1. J.D. Carpinelli, Computer Systems Organization & Architecture, Addison Wesley, 2001 2. S. Ribarić, Arhitektura računala RISC and CISC, Školska knjiga, Zagreb, 1996 3. J. L. Hennessy, D. Patterson, Computer Architecture, A Quantitative Approach, Morgan Kaufmann Pub., San Mateo, CA, 1996
Recommended additional literature:	1. D. Sima, T. Fountain, P. Kacsuk, Advanced Computer Architectures- A Design Space Approach, Addison Wesley, 1997 2. V.P. Heuring, H.F. Jordan, Computer Systems Design and Architecture, Addison Wesley, 1997
Prerequisites:	Computer Architecture
Teaching methods:	Lectures (30 hours), individual work with students pertaining to their respective seminar papers (15 hours).
Student assessment and examination methods:	Seminar paper and oral examination.
Course assessment:	Doctoral Committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

ZEUK06 EMBEDDED COMPUTER SYSTEMS	
Lecturer:	**Dr. Tomislav Keser, Assistant Professor**
ECTS credits:	6 ECTS lecture attendance: 1.5 ECTS seminar paper: 3 ECTS oral examination: 1.5 ECTS
Knowledge and skills acquired:	Knowledge of methods of building embedded computer systems, as well as methods used for their testing, validation and verification.
Course contents:	Microprocessor, microcontroller and digital signal processor. Special features of embedded systems. Building of embedded systems. Hardware development tools. Software development tools. Reliability and safety of embedded systems. Testing, validation and verification of embedded systems. Applications. Examples and programming of some embedded systems based on 8-, 16- and 32-bit microprocessors, and 8-, and 16-bit microcontrollers and digital signal processors.
Obligatory literature:	1. S. Ribarić, Naprednije arhitekture mikroprocesora, Element, Zagreb, 1997 2. L. Budin, Mikroračunala i mikroupravljači, Element, Zagreb, 1997 3. G. Smiljanić, 32-bitna mikroračunala, Element, Zagreb, 1993 4. S. Ribarić, Arhitektura mikroprocesora, Tehnička knjiga, Zagreb, 1988 5. R.Y. Kain, Computer architecture, Prentice-Hall, 1989
Recommended additional literature:	1. B.B. Brey, The Z-80 Microprocessor, Hardware, Software, Programming and Interfacing, Prentice Hall, 1988 2. F.F. Driscoll, Introduction to 6800/68000 microprocessors, Breton Publishers, 1987
Prerequisites:	Computer Architecture
Teaching methods:	Lectures (30 hours), individual work with students pertaining to their respective seminar papers (15 hours).
Student assessment and examination methods:	Seminar paper and oral examination.
Course assessment:	Doctoral Committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

ZEUK07 DATABASES AND COMPUTER NETWORKS	
Lecturer:	**Dr. Josip Job, Assistant Professor** **Dr. Damir Blažević, Assistant Professor**
ECTS credits:	6 ECTS lecture attendance: 2 ECTS seminar paper: 2 ECTS oral examination: 2 ECTS
Knowledge and skills acquired:	Knowledge of various models and databases and their application. Computer network design and quality of service management.
Course contents:	Information system, data model, process model, resource model. Conceptual, logical and physical design. Entity-relationship model. Process description, analysis and development. One-to-one, one-to-many and many-to-many performance relationship. Relational algebra. SQL. Normalisation. Object, object-relational, spatial and temporal databases. NoSQL databases. NewSQL. Distributed databases. Databases in a computer network. Computer networks and their implementation. Quality of Service in computer networks.
Obligatory literature:	1. R. Elmasri, S.B. Navathe: Fundamentals of Database Systems, Addison-Wesley, 2000 2. P. J. Sadalage, M. Fowler, NoSQL Distilled: A Brief Guide to the Emerging World of Polyglot Persistence, Addison-Wesley Professional, 2012 3. L.L.Peterson, B.S. Davie, Computer Networks: A Systems Approach, Morgan Kaufmann, Burlington (Massachusetts), 2012
Recommended additional literature:	1. Michael J. Hernandez, Database Design for Mere Mortals: A Hands-On Guide to Relational Database Design (3rd Edition), Addison-Wesley Professional, 2013 2. H. Garcia-Molina, J.D. Ullman, J. Widom: Database System: The Complete Book (2nd Edition), Prentice-Hall, 2008 3. Szigeti T., Hattingh C., End-to-End QoS Network Design: Quality of Service in LANs, WANs, and VPNs, Cisco Press, 2004
Prerequisites:	
Teaching methods:	Lectures (30 hours), individual work with students pertaining to their respective seminar papers (15 hours).
Student assessment and examination methods:	Seminar paper and oral examination.
Course assessment:	Doctoral Committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

ZEUK08 INTELLIGENT MANUFACTURING SYSTEMS	
Lecturer:	**Dr. Krešimir Nenadić, Assistant Professor**
ECTS credits:	6 ECTS lecture attendance: 1.5 ECTS seminar paper: 3 ECTS oral examination: 1.5 ECTS
Knowledge and skills acquired :	Knowledge of methods and applications of artificial intelligence in power systems.
Course contents:	Introduction to artificial intelligence. Overview of artificial intelligence applications. Knowledge, general terms, importance of knowledge, knowledge-based systems. Knowledge representation. Organisation and knowledge management. Knowledge acquisition. AI languages: LISP and PROLOG. Syntax and semantics of AI languages. Examples from electric power systems. Knowledge representation in electric power systems. Deductive and nondeductive decision methods. Working with inconsistencies and incomplete systems: truth maintenance system. Closed world assumptions. Modal, temporal and fuzzy logic. Probabilistic type decisions: Bayes' decision, possible worlds, Damster- Shafer theory, ad-hoc and heuristic methods. Structured knowledge: graphs, frames and similar structures. Organisation and knowledge management in electric power systems. Organisation and knowledge management: indexing, acquisition techniques, system knowledge integration, knowledge base organisation. Usability theory. Application: power system maintenance; generation, transmission and distribution of electric and heath energy; plant diagnostics; intelligent on-line decisions in power system control; expert systems for small industrial power plants.
Obligatory literature:	1. F. Jović, Expert Systems in Process Control, Chapman and Hall, London, Van Nostrand Reinhold Inc., New York, 1992, p. 175 2. W. Dan Patterson,: Introduction to Artificial Intelligence, Prentice Hall, New York, 1990, p. 448
Recommended additional literature:	1. IEEE Trans. On Expert Systems 2. IEEE Trans on Systems, Man and Cybernetics
Teaching methods:	
Student assessment and examination methods:	Lectures (30 hours), individual work with students pertaining to their respective seminar papers (15 hours).
Course assessment:	Writing and presenting the seminar paper.
Obligatory literature:	Doctoral Committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

ZEUK09 MULTIMEDIA COMPUTER SYSTEMS	
Lecturer:	**Dr. Goran Martinović, Full Professor** **Dr. Snježana Rimac-Drlje, Full Professor**
ECTS credits:	6 ECTS lecture attendance: 1.5 ECTS seminar paper: 3 ECTS oral examination: 1.5 ECTS
Knowledge and skills acquired:	Knowledge of architecture of processing units used for multimedia processing and the application of complex algorithms for image, video and sound compression.
Course contents:	Overview of problems and solutions which occur when using multimedia systems and general analyses of necessary resources (space and processor time). Overview of basic and advanced data compression algorithms. Lossless and lossy compression. Basics of human audio and video perception and their influence on compression algorithm development. Overview of the most important standards: JPEG, JPEG2000, MPEG-2 (video, Layer III audio-MP3, AAC), MPEG-4, MPEG-7. Comparison of classical and advanced realisation of some typical algorithms. Design and evaluation of multimedia systems according to application analysis: hardware and software demands. General purpose and special processor types: ASIC, MM coprocessors and general purpose processors extensions, DSP. Examples of operation execution on the mentioned processors. Operating systems in multimedia applications. Multimedia in distributed computer systems, middleware level. Multimedia servers. Building a multimedia system in wireless and mobile networks. Computer supported cooperative work and multimedia.
Obligatory literature:	1. C. Fogg, D.J. Le Gall, J. L. Mitchel, W.B. Pennebaker, MPEG video compression standard, Kluwer, Norwell, 2002 2. M. Kahrs (Ed): Applications of Digital Signal Processing to Audio and Acoustics, Kluwer Academic Publishers, 1998 3. R. Steinmetz, K. Nahrstedt, Multimedia Systems, Springer-Verlag, 2004 4. A. Bateman, I Paterson-Stephens, The DSP Handbook: Algorithms, Applications and Design Techniques, Prentice Hall, 2002 5. A. K. Salkintzis, N. Passas, Emerging Wireless Multimedia Services and Technologies, Wiley, 2005
Recommended additional literature:	1. N. Jayant, P. Noll: Digital Coding of Waveforms: Principles and applications to speech and video, Prentice Hall, 1991 2. B. Furht, S. W. Smoliar, H. Zhang: Video and Image Processing in Multimedia Systems, Kluwer, 1995 3. B. Pennbaker, J.L. Mitchel: JPEG, Van Nostrand Reinhold, 1992 4. B. Eylert, The Mobile Multimedia Business: Requirements and Solutions, Wiley, 2005 5. M.E.S. Morris, Multimedia Systems, Springer-Verlag, 2000
Prerequisites:	Multimedia communications, Computer architecture.
Teaching methods:	Lectures (30 hours), individual work with students pertaining to their respective seminar papers (15 hours).
Student assessment and examination methods:	Seminar paper and oral examination.
Course assessment:	Doctoral Committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

ZEUK10 COMPUTER GRAPHICS	
Lecturer:	**Dr. Irena Galić, Associate Professor**
ECTS credits:	6 ECTS lecture attendance: 1.5 ECTS seminar paper: 3 ECTS oral examination: 1.5 ECTS
Knowledge and skills acquired:	Knowledge of format, language, programming and application of computer graphics, animation and holograms, and connection with the Internet.
Course contents:	Vector and pixel graphics. Fractal graphics. Graphics programming. RGB/CMYK colour transformations. Image and transformation formats: TIFF, JPG, PDF, PICT. Image compression. Graphical programming languages. PostScript. Raster graphics and programming. Animation, tools, software support. 3D digitalisation, 3D solid modelling, scene and material design, stage lighting and rendering. Computer design. Computer graphics for the Internet. XML graphics technology. Transformation schemes; web and print graphics. Digital holography programming.
Obligatory literature:	Up-to-date literature will be provided as WWW at the beginning of classes.
Recommended additional literature:	
Prerequisites:	
Teaching methods:	Lectures (30 hours), individual work with students pertaining to their respective seminar papers (15 hours).
Student assessment and examination methods:	Lectures take place in parallel with testing of all chapters.
Course assessment:	Doctoral Committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

ZEUK11 INTELLIGENT ROBOTIC SYSTEMS	
Lecturer:	**Dr. Robert Cupec, Full Professor**
ECTS credits:	6 ECTS lecture attendance: 1.5 ECTS seminar paper: 3 ECTS oral examination: 1.5 ECTS
Knowledge and skills acquired:	Basic knowledge of robot manipulator control. Knowledge needed for the design of a navigation system of an autonomous mobile robot, which relies on the data obtained by different sensors. Knowledge about basic principles of robot vision and artificial intelligence which can be applied to increase the autonomy of the robot.
Course contents:	Control of the robot manipulators. Impedance control. Problem of mobile robot navigation: path planning and obstacle avoidance. Locomotion of mobile robots. Sensors used in mobile robot navigation. Measurement uncertainty. Fusion of data obtained by different sensors. Robot localisation. Environment map building based on sensor data. Robot motion planning. Basics of coordination between autonomous mobile robots. Robot vision. Visual serving. Artificial intelligence in robotics.
Obligatory literature:	1. J. J. Craig, Introduction to Robotics: Mechanics and Control, Addison-Wesley Publishing Company, Inc., 1989 2. Roland Siegwart and Illah Nourbakhsh: Introduction to Autonomous Mobile Robots, The MIT Press, A Badford Book, 2004
Recommended additional literature:	1. Z. Kovačić, S. Bogdan, V. Krajči, Osnove robotike, Graphis Zagreb, 2002 2. J. C. Latombe, Robot Motion Planning, Norwell, Massachusetts, USA: Kluwer Academic Publishers, 1991 3. O. Faugeras, Three-Dimensional Computer Vision: A Geometric Viewpoint. Cambridge, Massachusetts: The MIT Press, 1993 4. S. J. Russell, P. Norvig, Artificial Intelligence: A Modern Approach, Prentice Hall, Upper Saddle River, New Jersey, 1995
Prerequisites:	Linear algebra, Differential and integral calculus, Basics of rigid body mechanics, Probability and statistics, Basics of computers and programming, English
Teaching methods:	Lectures (30 hours), individual work with students pertaining to their respective seminar papers (15 hours).
Student assessment and examination methods:	Seminar paper and oral examination.
Course assessment:	Doctoral Committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

ZEUK12 REAL-TIME COMPUTER SYSTEMS IN CONTROL	
Lecturer:	**Dr. Matjaž Colnarič, Full Professor**
ECTS credits:	6 ECTS lecture attendance: 1.5 ECTS seminar paper: 3 ECTS oral examination: 1.5 ECTS
Knowledge and skills acquired:	Specific characteristics of real-time systems, tasks and multitasking, scheduling, synchronisation. Development and use of real-time systems. Assurance of safety, fault management and tolerance.
Course contents:	Definition and types of real-time systems. Specific properties: timeliness, predictability, dependability, limited resources. Time in embedded systems. Tasks, life cycle, multitasking. Synchronisation between real-time tasks. Scheduling of real-time tasks. Specific characteristics of hardware, software and communications in real-time systems. Programming languages for embedded systems development. Fault tolerance - guidelines, methods. Advanced selected topics for seminar papers. Distributed real-time systems. Middleware for embedded systems. Codesign of hardware and software subsystems. Design of real-time applications – UML-RT. Analysis of temporal requirements and performance (WCET, schedulability analysis). Dependability and dealing with faults: guidelines and standards for assuring dependability of computer systems. Dealing with exceptions in embedded systems. Specific areas of application of embedded systems: industrial, automotive, intelligent home, wearable, ubiquitous, pervasive applications.
Obligatory literature:	1. A. Burns, A. Wellings, Real-Time Systems and Their Programming Languages, Addison Wesley Longman, 1996 2. J. Cooling, Software Engineering for Real-Time Systems, Addison Wesley, 2002 3. Storey, Safety Critical Computer Systems. Addison Wesley, 1996 4. M. Colnarič, Lecture notes (in Slovene), www.rts.uni-mb.si, yearly updated. 5. Monograph to appear with Springer in 2006
Recommended additional literature:	Materials from the Internet.
Prerequisites:	Computer architecture, Embedded computer systems.
Teaching methods:	Lectures (30 hours), individual work with students pertaining to their respective seminar papers (15 hours).
Student assessment and examination methods:	Seminar paper and oral examination.
Course assessment:	Doctoral Committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

ZEUK13 DIGITAL VIDEOCOMMUNICATION	
Lecturer:	**Dr. Snježana Rimac-Drlje, Full Professor**
ECTS credits:	6 ECTS lecture attendance: 1.5 ECTS seminar paper: 3 ECTS oral examination: 1.5 ECTS
Knowledge and skills acquired:	Knowledge of advanced techniques for video processing and compression as well as existing standards for transmission and storage of video signals.
Course contents:	Image as a two-dimensional signal. Properties of 2D Fourier transformation. Discrete cosine transform. 2D digital filters, subband filtering, wavelets. Time and space correlation of the video signal. Model of the human visual system; perception of colours and motion. Video coding techniques: predictive, transform, subband coding, vector quantisation. Advanced methods: multiresolution coding, perceptual coding, fractals. Moving vector calculation, motion estimation and compensation. Standards for video communication systems: MJPEG, MPEG-1, MPEG-2, MPEG-4, MPEG-7, MPEG-21, H.263, H. 264.
Obligatory literature:	1. C. Fogg, D.J. Le Gall, J. L. Mitchel, W.B. Pennebaker, MPEG video compression standard, Kluwer, Norwell, 2002 2. R. Steinmetz, K. Nahrstedt: Multimedia Fundamentals: Media coding and Content processing, Prentice-Hall, 2002 3. K. R. Rao, Multimedia Communication Systems: Techniques, Standards, and Networks, Prentice Hall PTR, 2002
Recommended additional literature:	1. N. Jayant, P. Noll: Digital Coding of Waveforms: Principles and applications to speech and video, Prentice Hall, 1991 2. 1. B. Furht, S. W. Smoliar, H. Zhang: Video and Image Processing in Multimedia Systems, Kluwer, 1995 3. D. E. Dudgeon, R. M. Mersereau, Multidimensional digital signal processing, Prentice-Hall, Englewood Cliffs, 1984 4. G. Strang, T. Nguyen, Wavelets and filter banks, Wellesley Cambridge Press, 1996
Prerequisites:	Multimedia communications, Codes and coding
Teaching methods:	Lectures (30 hours), individual work with students pertaining to their respective seminar papers (15 hours).
Student assessment and examination methods:	Seminar paper and oral examination.
Course assessment:	Doctoral Committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

ZEUK14 MODERN RADIO-COMMUNICATION SYSTEM ARCHITECTURES	
Lecturer:	**Dr. Tomislav Švedek, Full Professor**
ECTS credits:	6 ECTS lecture attendance: 1.5 ECTS seminar paper: 3 ECTS oral examination: 1.5 ECTS
Knowledge and skills acquired:	Knowledge of new modern radio-communication architectures with multiple access, analysis and synthesis of heterodyne, homodyne and reconfigurable radio receivers, as well as methods of coding mono/stereo audio signal for the purpose of reducing the data transmission rate.
Course contents:	Frequency Division Multiple Access – FDMA, Time Division Multiple Access – TDMA and Code Division Multiple Access – CDMA. Spread spectrum radio-communication systems with Direct Sequence (DS) and Frequency Hopping (FH). Digital radio broadcasting in AM frequency bands under 30 MHz (Digital Radio Mondiale concept). Heterodyne radio receivers with conversion to intermediate frequency, homodyne radio receivers with direct conversion to base-band, and programme reconfigurable radio receivers (Soft-radio). Soft-radio key features: layered architecture of radio receiver, extern fast A/D conversion, flexible input RF section, effective procedure of data management (DSP). Reduction of data transmission rate by base-band source coding: Advanced Audio Coding - AAC for mono and stereo audio signals (20 kbit/s), Code Excited Linear Prediction - CELP (4 do 20 kbit/s) and Harmonic Vector eXcitation Coding - HVXC for speech (from 2 kbit/s). Spectral Band Replication - SBR tool for enhancement of perceptual quality of audio signals.
Obligatory literature:	1. E.A. Lee, D.G. Messerschmitt, Digital Communication, Boston, MA:Kluwer, 1994 2. T.S.Rappaport, Wireless Communications, Principles and Practice, Prentice-Hall, Inc. 1996
Recommended additional literature:	1. J.Crols, M.Steyyaert, CMOS Wireless Transceiver Design, Boston, MA:Kluwer, 1997
Prerequisites:	Electronic circuits, Microelectronics
Teaching methods:	Lectures (30 hours), individual work with students pertaining to their respective seminar papers (15 hours).
Student assessment and examination methods:	Seminar paper and oral examination.
Course assessment:	Doctoral Committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

ZEUK15 QUALITY OF SERVICE IN THE INTERNET	
Lecturer:	**Dr. Drago Žagar, Full Professor**
ECTS credits:	6 ECTS lecture attendance: 1.5 ECTS seminar paper: 3 ECTS oral examination: 1.5 ECTS
Knowledge and skills acquired:	Knowledge of technologies that ensure appropriate Quality of Service in the Internet. By successful course completion students will gain knowledge necessary for their future independent research in this field.
Course contents:	Basic QoS concept. Basic QoS parameters. Quality of service in telecommunication network. Quality of service in ATM network. Classification of applications and QoS requirements. Classification of multimedia applications. Quality of service from the user standpoint. Quality of service from the network standpoint. Quality of service from the application standpoint. QoS classes. Applications and services in the IP environment. Basic QoS building blocks: rate shaping, packet classification, packet scheduling and admission control. QoS and resource management. Resource management on the network level – RSVP protocol. Resource management on the end system level: adaptive and proactive applications and systems. QoS negotiation. The user - network QoS specification. Application – network QoS parameters translation. Service Level Agreement SLA. Network performance and QoS measurements. Basic QoS models: Intserv model and Diffserv model. Hybrid models. Flow management and performance optimisation: MPLS and traffic engineering. Some prospective of QoS implementation.
Obligatory literature:	1. Z. Wang, Internet QoS, Architectures and Mechanisms for Quality of Service, Morgan Kaufmann Publishers, San Francisko, USA, 2001 2.D. Verma, Supporting Service Level Agreements on IP Networks, Macmillan Technical Publishing, Indianapolis, USA, 1999
Recommended additional literature:	
Prerequisites:	
Teaching methods:	Lectures (30 hours), individual work with students pertaining to their respective seminar papers (15 hours).
Student assessment and examination methods:	Seminar paper and oral examination.
Course assessment:	Doctoral Committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

ZEUK16 WIDEBAND NETWORKS FOR MULTIMEDIA SERVICES	
Lecturer:	**Dr. Mario Vranješ, Assistant Professor**
ECTS credits:	6 ECTS lecture attendance: 1.5 ECTS seminar paper: 3 ECTS oral examination: 1.5 ECTS
Knowledge and skills acquired:	Knowledge of wideband networks structure and possibilities of their application in multimedia.
Course contents:	Introduction to multimedia services. Components of the multimedia system. Types of multimedia networks: ATM, IP, radio transmission, mobile and satellite networks, broadcasting. Modulations for the digital television broadcasting transmitters. Planning of digital radio broadcasting networks. Single frequency radio networks. Influence of higher harmonics. Videoconferencing, distance learning, publishing, multimedia in medicine.
Obligatory literature:	1. D.H. Morais: Fixed Broadband Wireless Communications, Pretnice Hall, 2004 2. K.R. Rao, Z.S. Boljkovic: Multimedia Communication Systems, Prentice Hall PTR 2002
Recommended additional literature:	1. R. Steinmentz, K. Nahrstedt: Media Coding and Content Processing, 2002, IMSC Press, Multimedia Series
Prerequisites:	Multimedia communications, Digital communication systems.
Teaching methods:	Lectures (30 hours), individual work with students pertaining to their respective seminar papers (15 hours).
Student assessment and examination methods:	Seminar paper and oral examination.
Course assessment:	Doctoral Committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

ZEUK17 XML PUBLISHING TECHNOLOGIES	
Lecturer:	**Dr. Vilko Žiljak, Full Professor**
ECTS credits:	6 ECTS lecture attendance: 1.5 ECTS seminar paper: 3 ECTS oral examination: 1.5 ECTS
Knowledge and skills acquired:	Knowledge of XML technology and its application in Internet databases.
Course contents:	Web technologies vs. the Internet vs. databases. Creating a Native database dictionary. XML database design. Archive and search by Xmeans of XSL /XSLT tools. Digital images, illustrations, documents databases. XML methods of conventional, digital and electronic publishing. Planning and Web design of new publishing projects. Organisation of servers in application: Offline, Intranet, Internet. Electronic XML - Web questionnaire. Interactive communication and XML technologies. XML and databases: Informix, XSQL, DB2, Access, and Native databases: Tamino, DBDOM.
Obligatory literature:	Up-to-date literature will be provided as WWW at the beginning of classes.
Recommended additional literature:	
Prerequisites:	
Teaching methods:	Lectures (30 hours), individual work with students pertaining to their respective seminar papers (15 hours).
Student assessment and examination methods:	Project task and oral examination.
Course assessment:	Doctoral Committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

ZEUK18 DEVELOPMENT AND APPLICATION OF ERP SYSTEMS	
Lecturer:	**Dr. Vlado Majstorović, Full Professor**
ECTS credits:	6 ECTS lecture attendance: 1.5 ECTS seminar paper: 3 ECTS oral examination: 1.5 ECTS
Knowledge and skills acquired:	Knowledge and application of the ERP system for preparation, production and service activities in enterprises.
Course contents:	Concept of ERP (Enterprise Resource Planning) system. Integration of functions and data. Planning and schedule of function operations and necessary resources. Management of preparation, production and service activities in enterprises. Structure of an ERP system: integrated information system, communication system and computer basics. Data organisation: relational database and data warehouse. ERP subsystems: sales and calculation, product structure and technology, work order launching, purchasing and inventory, production, production planning and monitoring, quality management, asset maintenance, financing and accounting, bookkeeping and delivery. Management (preparation and production) and selection models (suppliers, process planning variant, plan variant). Management subsystems. Specific characteristics of the ERP system for different production types (single, serial) and designs (metal, construction, process, electrical, wood, food) and services (transport, maintenance, energy and gas distribution, etc.). ERP II system basics. Integration of CAD, CAM, CAPP and ERP. Concept of CRM (Customer Relationship Management), ERM (Enterprise Resource Management) and EAI (Enterprise Application Integration). Applying new IT solutions in ERP (RF terminals, Internet WAP, e-business).
Obligatory literature:	1. N. Majdandžić, Izgradnja informacijskih sustava proizvodnih poduzeća, Slavonski Brod, Strojarski fakultet, Sveučilišta u Osijeku, 2004, p. 455
Recommended additional literature:	1. N. Majdandžić, R. Lujić, G. Matičević, G. Šimunović, I. Majdandžić, Upravljanje proizvodnjom, Slavonski Brod, Strojarski fakultet, Sveučilišta u Osijeku, 2001, p. 356
Prerequisites:	
Teaching methods:	Lectures (30 hours), individual work with students pertaining to their respective seminar papers (15 hours).
Student assessment and examination methods:	Seminar paper and oral examination.
Course assessment:	Doctoral Committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

ZEUK19 MULTIPROCESSOR AND PARALLEL SYSTEMS	
Lecturer:	**Dr. Željko Hocenski, Full Professor**
ECTS credits:	6 ECTS lecture attendance: 1.5 ECTS seminar paper: 3 ECTS oral examination: 1.5 ECTS
Knowledge and skills acquired:	Knowledge of the area of computer science that deals with multiprocessor and parallel computer architectures. Knowledge of specificities of architecture and communications within multiprocessor architectures, parallel computing and parallel algorithms. Skills in parallel programme design and work with multiprocessor operating systems. Knowledge and skills in CUDA and GPGPU for parallel data processing.
Course contents:	Communication in computer systems. Communication protocols. Single or multiple host computer buses. Basic types of multiprocessor system architectures. Operating systems and multiprocessor software execution. Synchronisation of approaches to common resources. MISD, SIMD and MIMD architecture. Systolic fields. Data flow computer systems. High parallel computer systems. Artificial neural networks. Learning methods and strategies in artificial neural networks. Brain-based model. CMAC information processing. CMAC learning algorithm. Real-time multiprocessing systems. NVIDIA CUDA platform. ATI STREAM platform. GPGPU programming. Fault-tolerance in multiprocessor systems. Some applications of multiprocessor and parallel systems.
Obligatory literature:	1. S. Ribarić, Arhitektura računala, Školska knjiga, Zagreb, 1990 2. K. Hwang, D. Degroot, (eds.), Parallel Processing for Supercomputers and Artificial intelligence, McGraw-Hill Pub. Company, New York, 1989 3. Cook, Shane; CUDA programming: a developer's guide to parallel computing with GPUs, San Francisco, California, Morgan Kaufmann Publishers Inc., 2013 4. Munshi, Aaftab; Gaster, Benedict; Mattson, Timothy; Fung, James; Ginsburg, Dan; OpenCL Programming Guide, San Francisco, California, Addison-Wesley Professional, 2012
Recommended additional literature:	1. D. Gajski . (eds), Computer Architecture, IEEE Computer Society Press, Washington, 1986 2. D.P. Agrawal, Advanced Computer Architecture, IEEE Computer Society Press Washington, 1986 3. J.L. Hennessy, D.A. Patterson, Computer Architecture, A Quantitative Approach, Morgan Kaufmann Pub. Inc. San Mateo, 1990 4. NVIDIA Corporation; NVIDIA CUDA programming guide, NVIDIA Corporation, Santa Clara, California, USA, 2012
Prerequisites:	
Teaching methods:	Lectures (30 hours), individual work with students pertaining to their respective seminar papers (15 hours).
Student assessment and examination methods:	Seminar paper and oral examination.
Course assessment:	Doctoral Committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

ZEUK20 SOFTWARE QUALITY ASSURANCE	
Lecturer:	**Dr. Damir Blažević, Assistant Professor** **Dr. Ivica Lukić, Assistant Professor**
ECTS credits:	6 ECTS lecture attendance: 1.5 ECTS seminar paper: 3 ECTS oral examination: 1.5 ECTS
Knowledge and skills acquired:	Knowledge of methods and applications of software project planning, organisation and management, software support verification, validation and testing.
Course contents:	Levels of software quality. Implementation and documentation of the quality system. Software quality management. Measurement of internal and external software quality attributes. Usage, need and the role of software quality assurance, software quality assurance plan. Software norms, organisation for norms, norms ANSI/IEEE, ISO, ESA PSS-05. Planning, organisation and management of a software project. Documentation of control methods. Management of changes and software configuration. Software life-cycle and life-cycle models. Verification, validation and testing. Process modelling. Process improvement. CMM method. Bootstrap and SPICE methods. Comparison of process improvement methods.
Obligatory literature:	1. Crosby P. B.: Quality is Free, New York, New American Library, 1979 2. Fenton N. E.: Software Metrics, A Rigorous Approach, Thomson Computer Press, 1995 3. Grady, Robert B.: Practical Software Metrics for Project Management and Process Improvement, Prentice Hall 1992 4. Slavek N.: Osiguranje kvalitete programske podrške, Elektrotehnički fakultet Osijek, 2016
Recommended additional literature:	
Prerequisites:	
Teaching methods:	Lectures (30 hours), individual work with students pertaining to their respective seminar papers (15 hours).
Student assessment and examination methods:	Seminar paper and oral examination.
Course assessment:	Doctoral Committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

ZEUK25 COMPONENT-BASED SOFTWARE SYSTEMS	
Lecturer:	**Dr. Ivica Crnković, Full Professor**
ECTS credits:	6 ECTS lecture attendance: 1.5 ECTS seminar paper: 3 ECTS oral examination: 1.5 ECTS
Knowledge and skills acquired:	Understanding trends in the development of component-based software systems. Knowledge of principles of component models based on requirements in different engineering fields. Familiarising with challenges and possible solutions. Writing and reviewing research papers and presenting the respective papers as seminar papers.
Course contents:	Basic principles of component-based software systems and their implementation. Component-based technologies (COM/DCOM, .NET, EJB, CORBA). Specification of software components: interface, functional and non-functional. Component interaction. Software architecture. Composition of components and their features – component modelling and prediction of component features. Component-based development process. Components for embedded systems and real-time systems. Problems and research challenges of the component-based approach.
Obligatory literature:	1. I. Crnkovic, M. Larsson, Building Reliable Component-Based Software Systems, Artech House Publishers, 2002 2. C. Szyperski, Component Software - Beyond Object-Oriented Programming – Second Edition, Addison-Wesley/ACM Press, 2002 3. Radovi s konferencija poput «Sypmosia on Component-Based Software Engineering»
Recommended additional literature:	1. G.T. Heineman, W.T. Councill, Putting Pieces togehter, Addison Wesley Copyright: 2001 2. Don Box Essential COM, Addison-Wesley Professional, 1997 3. J. Siegel, CORBA 3 Fundamentals and Programming, John Wiley & Sons, 2000 3. T. Thai, H. Lam, NET Framework Essentials, O'Reilly; 2002 4. R. Monson-Haefel, Enterprise JavaBeans, O'Reilly; 2001 5. Papers from different conferences on software engineering (ICSE, ESEC/FSE, Euromicromo SEAA)
Prerequisites:	Object-oriented programming, experience in software modelling.
Teaching methods:	Lectures (30 hours), individual work with students pertaining to their respective seminar papers (15 hours).
Student assessment and examination methods:	Seminar paper and oral examination.
Course assessment:	Doctoral Committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

ZEUK26 COMPUTER SYSTEMS FOR REAL-TIME SIGNAL PROCESSING	
Lecturer:	**Dr. Ivan Aleksi, Assistant Professor** **Dr. Tomislav Matić, Assistant Professor** **Dr. Dieter Kraus, Full Professor** **Dr. Željko Hocenski, Full Professor**
ECTS credits:	6 ECTS lecture attendance: 1 ECTS research: 3.5 ECTS oral examination: 1.5 ECTS
Knowledge and skills acquired:	Knowledge of real-time data processing systems and their architectures: CPU, DSP, GPU, GPP, FPGA, ASIC, SOC, SIP. Data sampling and algorithms for real-time processing: segmentation, filtering, features extraction and identification, real-time optimisation. Parallel implementation of algorithms for real-time applications on CPU, GPU, DSP, and FPGA. Development of embedded systems ASIC, SOC, SIP for real-time data processing.
Course contents:	Fundamentals of signal and image processing. Types of data and their acquisition. Real-time systems. Basics of GPU, CPU, DSP and FPGA computing platforms. Applications of specific platforms to practical real-time problems. Implementation of certain algorithms on different computer architectures. Real-time data processing: segmentation, filtering, feature extraction and identification, data analysis. Practical examples: face recognition, iris recognition, fingerprint recognition, etc. Introduction to software languages for parallel algorithm implementation: C++, CUDA, VHDL, MATLAB
Obligatory literature:	1. Uvais Qidwai, C.H. Chen: "Digital Image Processing, An Algorithmic Approach With MATLAB", Chapman & Hall, 2010. ISBN13: 978-1-4200-7950-0. 2. Robert Sedgewick, Kevin Wayne: "Algorithms," 4th edition, Addison-Wesley Professional, 2011. ISBN-13: 978-0321573513. 3. Sen M. Kuo, Bob H. Lee, Wenshun Tian: "Real-Time Digital Signal Processing: Fundamentals, Implementations and Applications," 3rd edition, Wiley, 2013. ISBN-13: 978-1118414323. 4. John C. Russ, J. Christian Russ: "Introduction to Image Processing and Analysis," CRC Press, 2007. ISBN-13: 978-0849370731.
Recommended additional literature:	1. Aaftab Munshi, Benedict Gaster, Timothy G. Mattson, James Fung, Dan Ginsburg: "OpenCL Programming Guide", Addison-Wesley Professional, 2011. ISBN-13: 978-0321749642. 2. Mark Nixon: "Feature Extraction & Image Processing for Computer Vision", 3rd edition, Academic Press, 2012. ISBN-13: 978-0123965493. 3. Thaddeus Baynard Welch III, Cameron H.G. Wright, Michael G. Morrow: "Real-Time Digital Signal Processing from MATLAB® to C with the TMS320C6x DSPs," 3rd edition, CRC Press, 2011. ISBN-13: 978-1439883037. 4. James Reinders: "Intel Threading Building Blocks: Outfitting C++ for Multi-core Processor Parallelism," O'Reilly Media, 2007. ISBN-13: 978-0596514808.
Prerequisites:	
Teaching methods:	Lectures (30 hours), individual work with students pertaining to their respective seminar papers (15 hours).
Student assessment and examination methods:	Evaluation of research competencies in the preparation of a research paper and oral examination.
Course assessment:	Doctoral Committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

ZEUK27 ALGORITHMS FOR DATA CLUSTERING	
Lecturer:	**Dr. Rudolf Scitovski, Full Professor**
ECTS credits:	6 ECTS lecture attendance: 1.5 ECTS research and writing a scientific paper: 4.5 ECTS
Knowledge and skills acquired:	Recognising basic methods of data clustering and their application, especially in pattern recognition. Implementation of Mathematica and Matlab codes.
Course contents:	Representative of the data. Problems of data clustering: motivation and applications. Basics of a distance-like function. Clustering the data into k clusters based on one or more attributes. Searching for an optimum partition: k-mean algorithm, global optimisation method, hierarchical agglomerative clustering algorithm, adaptive Mahalanobis algorithm, DBSCAN. Selection of the appropriate number of clusters-indexes. Fuzzy clustering. Applications (pattern recognition, especially geometric objects and non-convex patterns, image and signal analysis). Mathematica and Matlab codes.
Obligatory literature:	1. R.Scitovski, M.Briš Alić, Grupiranje podataka, Ekonomski fakultet u Osijeku, 2016., 2. .J.C.Bezdek, J.Keller, R.Krisnapuram, N.R.Pal, D.Dubois, H.Prade *(Eds.),* Fuzzy models and algorithms for pattern recognition and image processing, *Springer,* 2005
Recommended additional literature:	1. P.N.Tan, M.Steinbach, V.Kumar, Introduction to Data Mining, *Wesley*, 2006 2. S.Theodoridis, K.Koutroumbas, K. Pattern Recognition, *Academic Press, Burlington*, 2009 3. A.Morales-Esteban, F.Martínez-Álvarez, R.Scitovski, S.Scitovski, A fast partitioning algorithm using adaptive Mahalanobis clustering with application to seismic zoning, *Computers & Geosciences*, 2014, *73*, 132–141 4. J.Kogan, Introduction to Clustering Large and High-dimensional Data *Cambridge University Press, New York*, 2007 5. K.Sabo, R.Scitovski, I.Vazler, One-dimensional center-based l_1-clustering method, *Optimization Letters*, 2013, *7*, 5-22 6. R.Scitovski, T.Marošević, Multiple circle detection based on center-based clustering, *Pattern Recognition Letters*, 2014, *52*, 9-16 7. R.Scitovski, I.Vidović, D.Bajer, A new fast fuzzy partitioning algorithm, *Expert Systems with Applications*, 2016, *51*, 143-150 8. Dheeraj Kumar, James C. Bezdek, Marimuthu Palaniswami, Sutharshan Rajasegarar, Christopher Leckie, Timothy Craig Havens, A hybrid approach to clustering in big data, IEEE Ttransactions on cybernetics, 2015 9. M.Ester, H.Krieogel, J.Sander, A density-based algorithm for discovering clusters in large spatial databases with nosie, *2nd International Conference on Knowledge Discovery and Data Mining(KDD-96),* 1996, 226-231 10. R.Scitovski, K.Sabo, Analysis of the k-means algorithm in the case of data points occurring on the border of two or more clusters, Knowledge-Based Systems 57(2014), 1-7 11. R.Scitovski, Numerička matematika, Odjel za matematiku, Sveučilište u Osijeku, Osijek, 2004
Prerequisites:	
Teaching methods:	Lectures (30 hours), individual work with students pertaining to their respective seminar papers (15 hours).
Student assessment and examination methods:	Evaluating research competencies applied to preparing a research paper and oral examination.
Course assessment:	Doctoral Committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

ZEUK28 DATA SCIENCE	
Lecturer:	**Dr. Ratko Grbić, Assistant Professor** **Dr. Josip Job, Assistant Professor**
ECTS credits:	6 ECTS lecture attendance: 1.5 ECTS seminar paper: 2.5 ECTS oral examination 2 ECTS
Knowledge and skills acquired:	Knowledge of different methods and techniques for data management, data analysis and knowledge extraction from data and presentation of the obtained results. Learning appropriate skills with software tools and frameworks which enable data collection, integration and manipulation, data visualisation, statistical data analysis, data based modeling and prediction.
Course contents:	Introduction to data science. Problem definition and translation into the data problem. Data sources. Properties of the data. Data management. Data extraction and cleaning. Exploratory data analysis. Data visualisation. Statistical methods. Fundamentals of machine learning. Types of machine learning. Methods for data clustering and dimensionality reduction. Development of different predictive models. Big data analytics. Deep learning. Advanced optimisation methods. Results interpretation, presentation and reproducibility, decision making. Available software tools and platforms for data visualisation and data analytics (R, Python, d3.js, Tableau, Google TensorFlow etc.). Developing data products. Different applications.
Obligatory literature:	1. J. Grus, Data Science from Scratch: First Principles with Python, O'Reilly Media, 2015 2. S. Murray, Interactive Data Visualization for the Web, O'Reilly Media, 2013 3. 3. C.M. Bishop, Pattern Recognition and Machine Learning, Springer, 2007
Recommended additional literature:	1. T. Hastie, R. Tibshirani, J. Friedman, The Elements of Statistical Learning: Data Mining, Inference, and Prediction, Springer, 2009 2. S. Raschka, Python Machine Learning, Packt Publishing, 2015 3. R. D. Peng, R Programming for Data Science, Leanpub, 2015
Prerequisites:	
Teaching methods:	Lectures (30 hours), individual work with students pertaining to their respective seminar papers (15 hours).
Student assessment and examination methods:	Seminar paper and oral examination.
Course assessment:	Doctoral Committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.

ZEUK29 COMPUTING ENVIRONMENTS AND DATA ANALYSIS METHODS	
Lecturer:	**Dr. Goran Martinović, Full Professor**
ECTS credits:	6 ECTS lecture attendance: 1.5 ECTS seminar paper: 1 ECTS project: 1.5 ECTS oral examination: 2 ECTS
Knowledge and skills acquired:	Developing and applying distributed and service-oriented computer systems, methods and tools for efficient analysis of big data in business, research, industrial and other application domains.
Course contents:	Hardware and software operation requirements of distributed and service-oriented computer systems. Designing parallel and distributed algorithms. Management of resources, tools and users, reliability and safety. Defining a platform, infrastructure, application and presentation of data. Developing, testing and marketing a service. Utilising services and tools of public clouds. Big data. Detecting, storing, managing and processing big data. Methods of supervised, unsupervised and reinforcement learning and other methods of data-based learning. Using up-to-date analytical and implementation technologies and tools for data analysis. Connecting service environments with the Internet of Things (IoT) as a source of data. Applications in business, scientific, medical, industrial and other environments. Supervision, measurement and evaluation of distributed and service-oriented environments and data analysis.
Obligatory literature:	1. C.A. Varela, G. Agha, Programming Distributed Computing Systems: A Foundational Approach, MIT Press, 2013 2. B. Wilkinson, Grid Computing: Techniques and Applications, Chapman and Hall/CRC, 2009 3. M.J. Kavis, Architecting the Cloud: Design Decisions for Cloud Computing Service Models (SaaS, PaaS, and IaaS), Wiley, 2014 4. B. Baesens, Analytics in a Big Data World: The Essential Guide to Data Science and its Applications, Wiley, 2014
Recommended additional literature:	1. A. Osseyran, M. Giles, Industrial Applications of High-Performance Computing: Best Global Practices, Chapman and Hall/CRC, 2015 2. I. Foster, C. Kesselman, The Grid 2: Blueprint for a New Computing Infrastructure (2 izdanje), Morgan Kaufmann, 2004 3. J. Rhoton, R. Haukioja, Cloud Computing Explained: Implementation Handbook for Enterprises (2nd Ed.), Recursive Press, 2009 4. F. Provost, T. Fawcett, Data Science for Business: What You Need to Know about Data Mining and Data-Analytic Thinking, O'Reilly Media, 2013
Prerequisites:	
Teaching methods:	Lectures (30 hours), individual work with students pertaining to their respective seminar papers (15 hours).
Student assessment and examination methods:	Assessing the project and seminar paper, oral examination.
Course assessment:	Doctoral Committee assesses regularity and quality of the teaching process, tutorials as well as examination issues. An anonymous questionnaire filled in by doctoral students is done when required.