Catalogue report

Electrical Engineering DP

ITEE - Electronics and Communications Engineering

Degree structures

Degree Programme in Electronics and Communications Engineering, B.Sc.

Degree structure status: published

Academic year: 2019-20

Beginning date of the academic year: 01.08.2019

Basic and Intermediate Studies

A451120: Basic and Intermediate Studies, Electrical Engineering, 150 - 170 cp

Choice of second domestic language, written and spoken. Basic and Intermediate Studies are 124 ECTS cr (includes 2 ECTS cr Swedish and 4 ECTS cr English)

901048Y: Second Official Language (Swedish), Written Skills, 1 cp
901049Y: Second Official Language (Swedish), Oral Skills, 1 cp
900081Y: Second Official Language (Finnish), Written Skills, 1 - 2 cp
900082Y: Second Official Language (Finnish), Oral Skills, 1 - 3 cp

Choose the minimum of 4 ects of English or German modules

902150Y: Professional English for Technology, 2 cp
902142Y: Business Correspondence, 2 cp
902145Y: Working Life Skills, 2 cp
902147Y: Academic Vocabulary for Science and Technology, 2 cp
902149Y: Mechanics of Writing, 2 cp
903024Y: Elementary Course in German 1, 3 - 4 cp
903025Y: Elementary Course in German 2, 3 - 4 cp
903029Y: Intermediate Course in German 1, 3 - 4 cp
903030Y: Intermediate Course in German 2, 3 - 4 cp

Compulsory to all

521004P: Orientation to Electronics and Communications Engineering, 1 cp
031010P: Calculus I, 5 cp
521077P: Introduction to Electronics, 5 cp
521141P: Elementary Programming, 5 cp
031078P: Matrix Algebra, 5 cp
521109A: Electrical Measurement Principles, 5 cp
031075P: Calculus II, 5 cp
031021P: Probability and Mathematical Statistics, 5 cp
031076P: Differential Equations, 5 cp
BSc thesis and related studies (10 cp)

The extent of the BSc thesis in Electrical Engineering is 8 credits. Choose 523990A Electrical Engineering. Maturity exam and seminar presentation are also required.

- 523990A: Bachelor's Thesis / Electronics and Communications Engineering, 8 cp
- 521010A: Maturity Test for Bachelor's Degree, Electronics and Communications Engineering, 0 cp
- 521036A: Seminar for Bachelor’s Degree, Electronics and Communications Engineering, 0 cp
- 900060A: Technical Communication, 2 cp

Optional studies

Optional courses to complete the 180 credit degree can be selected e.g. from other engineering branches, natural sciences and business studies. Practical training, 3 credits, can also be included. Each student's optional studies are approved by programme administration. Some recommended courses in the Finnish language study guide. In more detail: http://www.oulu.fi/ee/opiskelu/valinnaiset

MSc. Engineering, Electronics and Communications Engineering

Degree structure status: published

Academic year: 2019-20

Beginning date of the academic year: 01.08.2019

Option (60 - 80 cp)

Compulsory, choose one of the options and one of the related advanced modules.
Apart from the below courses, the advanced module can contain also courses from other options as well as e.g. natural sciences or economics courses that support your degree. The minimum extent of the degree is 120 ECTS credits. Please observe this when selecting your optionals.

Please note: there may be mistakes in module size limits which will not affect your choices.

**Electronics Design**

H451229: Module of the Option, Electronics Design, 60 - 87 cp

*Compulsory*

A451221: Module of the Option, Electronics Design, 30 - 38 cp

*Compulsory studies, Total 33 ECTS cr*

- 521401S: Electronics Design II, 6 cp
- 521405A: Electronic System Design, 5 cp
- 521326S: Radio Engineering I, 5 cp
- 521088S: Optoelectronics, 5 cp
- 521423S: Embedded System Project, 5 cp
- 521406S: Digital Techniques 3, 7 cp

A451289: Advanced module/Electronics design, electronics design (obligatory), 15 - 40 cp

*Choose at least 15 ECTS cr*

- 521348S: Statistical Signal Processing 1, 5 cp
- 521435S: Electronics Design III, 6 cp
- 521453A: Operating Systems, 5 cp
- 521457A: Software Engineering, 5 cp
- 521025S: Power Electronics, 5 cp
- 521225S: RF Components and Measurements, 5 cp
- 521300S: Electronics Design and Construction Exercise, 6 cp
- 521402S: Telecommunications Circuit Design, 6 cp
- 521448S: Physical Design of Digital Integrated Circuits, 5 cp

*Choose optional Studies (39 ECTS cr or until the degree is 120 ECTS cr): Electronics*

- 521410S: Special Course in Electronic Design, 4 - 7 cp
- 521327S: Radio Engineering II, 6 cp
- 521388S: Antennas, 5 cp
- 521098S: Printed Electronics, 5 cp
- 521124S: Sensors and Measuring Techniques, 5 cp
- 521098S: Testing Techniques of Electronics and Printed Electronics, 5 cp
- 521328A: Simulations and Tools for Telecommunications, 5 cp
- 477624S: Control System Methods, 5 cp
- 521279S: Signal Processing Systems, 5 cp
- 521281S: Application Specific Signal Processors, 5 cp
- 812341A: Object-Oriented Programming, 5 cp

**Electronics materials and components**

H451226: Module of the Option, Electronics Materials and Components, 60 - 80 cp

*Compulsory*

A451222: Module of the Option, Electronics Materials and Components, 35 - 41 cp

*Module of the Option, Compulsory studies, 41 ECTS cr (Note: 521028S Small/medium power energy harvesting and storage devices will be lectured in odd years (-19, -21,...))*

- 521401S: Electronics Design II, 6 cp
- 521124S: Sensors and Measuring Techniques, 5 cp
- 521326S: Radio Engineering I, 5 cp
- 521028S: Small/Medium Power Energy Harvesting and Storage Devices, 5 cp
- 521075S: Microelectronics Packaging Technologies, 5 cp
521074S: Microelectronics and Micromechanics, 5 cp
521225S: RF Components and Measurements, 5 cp
521215S: Microelectronics project, 5 cp
A451291: Advanced Module, Electronics Materials and Components, 10 - 52 cp

Advanced module, Obligatory courses 20 ECTS cr
521080S: X-ray Diffraction, 5 cp
521072S: Microsensors, 5 cp
521079S: Introduction to Nanotechnology, 5 cp
521089S: Printed Electronics, 5 cp

Recommended optional studies 26 ECTS cr or until the degree is 120 ECTS cr, see http://www.oulu.fi/ee/opiskelu/oppaat
521435S: Electronics Design III, 6 cp
521405A: Electronic System Design, 5 cp
521406S: Digital Techniques 3, 7 cp
521423S: Embedded System Project, 5 cp
521300S: Electronics Design and Construction Exercise, 6 cp
521096S: Measuring Systems, 5 cp
521088S: Optoelectronics, 5 cp
521094S: Optoelectronic Sensors of Future, 5 cp
521098S: Testing Techniques of Electronics and Printed Electronics, 5 cp
521115S: EMC Design, 5 cp
521388S: Antennas, 5 cp
521386S: Radio Channels, 5 cp
521327S: Radio Engineering II, 6 cp
521402S: Telecommunications Circuit Design, 6 cp

Telecommunication Engineering

H453221: Module of the Option, Telecommunication Engineering, 60 - 80 cp

Module of the option, Telecommunication, Obligatory Studies 40 ECTS cr
A451224: Module of the Option, Telecommunication Engineering, 40 - 41 cp

Module of the Option. 40 ECTS cr
031051S: Numerical Matrix Analysis, 5 cp
521348S: Statistical Signal Processing 1, 5 cp
521395S: Wireless Communications I, 5 cp
031025A: Introduction to Optimization, 5 cp
521340S: Communications Networks I, 5 cp
521324S: Statistical Signal Processing II, 5 cp
521349S: Wireless Communications II, 5 cp
521326S: Radio Engineering I, 5 cp

Advanced module, obligatory courses, 30 ECTS cr
A453273: Advanced module, Telecommunication Engineering, 10 - 47 cp

Advanced module mandatory courses, choose min. 30 ECTS cr These are alternative:
521322S Telecommunication engineering project or 521300S Electronics design and construction exercise.
521386S: Radio Channels, 5 cp
521328A: Simulations and Tools for Telecommunications, 5 cp
521327S: Radio Engineering II, 6 cp
521377S: Communications Networks II, 7 cp
521388S: Antennas, 5 cp
521279S: Signal Processing Systems, 5 cp
521322S: Telecommunication Engineering Project, 5 cp
521300S: Electronics Design and Construction Exercise, 6 cp
521318S: Modern Topics in Telecommunications and Radio Engineering, 3 - 7 cp
521389S: Wireless Body Area Networks, 5 cp
521325S: Communication Signal Processing, 5 cp
521390S: Information Theory, 5 cp
521391S: Channel Coding and Modulation, 5 cp
521392S: Convex Optimization, 7 cp
521393S: Statistical Communication Theory, 7 cp
521394S: Multiantenna Communications, 5 cp

Optional Studies
A453295: Advanced Module, Telecommunication Engineering (optional studies), 11 - 37 cp

Optional studies, until the degree is full (120 ECTS cr)
555285A: Project management, 5 cp
555391S: Advanced Course in Project Management, 5 cp

RF-engineering

H453222: Modules of the option RF Engineering, 70 - 90 cp

Compulsory
A451226: Module of the option, RF Engineering, 36 - 71 cp

Obligatory studies: basic and advanced module, tot. 36 ECTS cr
521401S: Electronics Design II, 6 cp
521348S: Statistical Signal Processing 1, 5 cp
521395S: Wireless Communications I, 5 cp
521326S: Radio Engineering I, 5 cp
521324S: Statistical Signal Processing II, 5 cp
521225S: RF Components and Measurements, 5 cp
521405A: Electronic System Design, 5 cp

A451297: Advanced Module, Radio engineering, 36 - 42 cp

Radio engineering - advanced module
521435S: Electronics Design III, 6 cp
521327S: Radio Engineering II, 6 cp
521075S: Microelectronics Packaging Technologies, 5 cp
521388S: Antennas, 5 cp
521402S: Telecommunications Circuit Design, 6 cp

Obligatory, Radio engineering - advanced module, Choose 521322S Telecommunication engineering project or 521300S Electronics design and construction exercise
521322S: Telecommunication Engineering Project, 5 cp
521300S: Electronics Design and Construction Exercise, 6 cp

Optional studies: please select courses so that the minimum extent is 120 ECTS.
521386S: Radio Channels, 5 cp
521328A: Simulations and Tools for Telecommunications, 5 cp
521340S: Communications Networks I, 5 cp
521349S: Wireless Communications II, 5 cp
521289S: Machine Learning, 5 cp
521279S: Signal Processing Systems, 5 cp
521318S: Modern Topics in Telecommunications and Radio Engineering, 3 - 7 cp
521325S: Communication Signal Processing, 5 cp
521410S: Special Course in Electronic Design, 4 - 7 cp
555285A: Project management, 5 cp
555391S: Advanced Course in Project Management, 5 cp

Photonics and Measurement Techniques

H451227: Module of the Option, Photonics and Measurement Technology, 60 - 80 cp

Module of the option, compulsory studies, 31 ECTS cr
A451223: Module of the Option, Photonics and Measurement Techniques, 30 - 41 cp

Compulsory courses, 31 ECTS cr
521089S: Printed Electronics, 5 cp
521096S: Measuring Systems, 5 cp
521401S: Electronics Design II, 6 cp
521088S: Optoelectronics, 5 cp
521124S: Sensors and Measuring Techniques, 5 cp
521097S: Wireless Measurements, 5 cp

Advanced Modules, Optical and Electrical Measurement Techniques, 15 ECTS cr
A451292: Advanced Module, Optical and Electrical Measurement Techniques, 15 - 57 cp

Advanced module, Compulsory Studies 15 ECTS cr (Choose)
521242A: Introduction to Biomedical Engineering, 5 cp
521240S: Biophotonics and Biomedical Optics, 5 cp
521093S: Biomedical Instrumentation, 5 cp
521094S: Optoelectronic Sensors of Future, 5 cp
A451293: Advanced Module, Testing Techniques and Printed Electronics, 10 - 57 cp

Compulsory studies 15 ECTS cr
521115S: EMC Design, 5 cp
521098S: Testing Techniques of Electronics and Printed Electronics, 5 cp
521079S: Introduction to Nanotechnology, 5 cp

Optional Studies (41 ECTS cr): Photonics and measurement techniques. You must take the optional studies to make total 120 ECTS cr
521318S: Modern Topics in Telecommunications and Radio Engineering, 3 - 7 cp
521395S: Wireless Communications I, 5 cp

Advanced practical training (3 cp)
521016A: Advanced Practical Training, 3 cp

Master's Thesis (30 cp)
Choose your Thesis category among the following.
The Master's Thesis requires seminar and written maturity test.

MSc Thesis Electronics design
521362S: Electonics and Communications Engineering Seminar, 0 cp
523991S: Master's Thesis in Electronics Design, 30 cp
521011S: Maturity Test for Master's Degree, Electronics and Communications Engineering, 0 cp

MSc Thesis Electronics materials and components
521362S: Electonics and Communications Engineering Seminar, 0 cp
523992S: Master's Thesis in Electronics Materials and Components, 30 cp
521011S: Maturity Test for Master's Degree, Electronics and Communications Engineering, 0 cp

MSc Thesis Telecommunication
521362S: Electonics and Communications Engineering Seminar, 0 cp
521998S: Master's Thesis in Telecommunication Engineering, 30 cp
521011S: Maturity Test for Master's Degree, Electronics and Communications Engineering, 0 cp

MSc Thesis Radio engineering
521362S: Electonics and Communications Engineering Seminar, 0 cp
522991S: Master's Thesis in Radio Engineering, 30 cp
521011S: Maturity Test for Master's Degree, Electronics and Communications Engineering, 0 cp

MSc Thesis Photonics and measurement techniques
521362S: Electonics and Communications Engineering Seminar, 0 cp
523993S: Master's Thesis in Photonics and Measurement Technology, 30 cp
521011S: Maturity Test for Master's Degree, Electronics and Communications Engineering, 0 cp
Master's Programme in Wireless Communications Engineering

Degree structure status: published

Academic year: 2019-20

Beginning date of the academic year: 01.08.2019

Module of the option (40 cp)

Choose one of the available options. All courses are compulsory.

A451225: Module of the Option, Wireless Communications Engineering, 40 - 65 cp

obligatory studies of the RAN study option

031051S: Numerical Matrix Analysis, 5 cp
521348S: Statistical Signal Processing I, 5 cp
521395S: Wireless Communications I, 5 cp
031025A: Introduction to Optimization, 5 cp
521340S: Communications Networks I, 5 cp
521324S: Statistical Signal Processing II, 5 cp
521349S: Wireless Communications II, 5 cp
521326S: Radio Engineering I, 5 cp

A451226: Module of the option, RF Engineering, 36 - 71 cp

Obligatory studies: basic and advanced module, tot. 36 ECTS cr

521401S: Electronics Design II, 6 cp
521348S: Statistical Signal Processing I, 5 cp
521395S: Wireless Communications I, 5 cp
521326S: Radio Engineering I, 5 cp
521324S: Statistical Signal Processing II, 5 cp
521225S: RF Components and Measurements, 5 cp
521405A: Electronic System Design, 5 cp

Advanced Module (min 30 cp)

Radio Access Networks (WCE-RAN)

A453273: Advanced module, Telecommunication Engineering, 10 - 47 cp

Advanced module mandatory courses, choose min. 30 ECTS cr These are alternative:

521322S Telecommunication engineering project or 521300S Electronics design and construction exercise.

521386S: Radio Channels, 5 cp
521328A: Simulations and Tools for Telecommunications, 5 cp
521327S: Radio Engineering II, 6 cp
521377S: Communications Networks II, 7 cp
521388S: Antennas, 5 cp
521279S: Signal Processing Systems, 5 cp
521322S: Telecommunication Engineering Project, 5 cp
521300S: Electronics Design and Construction Exercise, 6 cp
521318S: Modern Topics in Telecommunications and Radio Engineering, 3 - 7 cp
521389S: Wireless Body Area Networks, 5 cp
521325S: Communication Signal Processing, 5 cp
521390S: Information Theory, 5 cp
521391S: Channel Coding and Modulation, 5 cp
521392S: Convex Optimization, 7 cp
521393S: Statistical Communication Theory, 7 cp
521394S: Multiantenna Communications, 5 cp
Radio engineering (WCE-RF)

A451297: Advanced Module, Radio engineering, 36 - 42 cp

Radio engineering - advanced module
- 521435S: Electronics Design III, 6 cp
- 521327S: Radio Engineering II, 6 cp
- 521075S: Microelectronics Packaging Technologies, 5 cp
- 521388S: Antennas, 5 cp
- 521402S: Telecommunications Circuit Design, 6 cp

Obligatory, Radio engineering - advanced module, Choose 521322S Telecommunication engineering project or 521300S Electronics design and construction exercise
- 521322S: Telecommunication Engineering Project, 5 cp
- 521300S: Electronics Design and Construction Exercise, 6 cp

Supplementary module/Electives, WCE (16 - 31 cp)

Choose from the set courses to reach the minimum of 120 ECTS degree (including the thesis and practical training).

A453246: Supplementary module/Electives, Wireless Communications Engineering, 10 - 41 cp

Radio engineering (WCE-RF): Optional courses, Choose 5 ECTS cr
- 521386S: Radio Channels, 5 cp
- 521328A: Simulations and Tools for Telecommunications, 5 cp
- 521340S: Communications Networks I, 5 cp
- 521349S: Wireless Communications II, 5 cp
- 521325S: Communication Signal Processing, 5 cp

WCE-RAN and WCE-RF
- 900017Y: Survival Finnish, 2 cp
- 900013Y: Beginners' Finnish Course 1, 3 cp
- 900053Y: Beginners' Finnish Course 2, 5 cp
- 521225S: RF Components and Measurements, 5 cp
- 521097S: Wireless Measurements, 5 cp
- 521389S: Wireless Body Area Networks, 5 cp
- 813621S: Research Methods, 5 cp
- 521273S: Biosignal Processing I, 5 cp
- 521282S: Biosignal Processing II, 5 cp
- 521467A: Digital Image Processing, 5 cp
- 521145A: Human-Computer Interaction, 5 cp
- 521045S: Mobile Computing, 5 cp
- 521043S: Internet of Things, 5 cp
- 521140S: Computer Graphics, 5 cp
- 521290S: Distributed Systems, 5 cp
- 521466S: Machine Vision, 5 cp
- 521156S: Towards Data Mining, 5 cp
- 521260S: Programmable Web Project, 5 cp
- 521479S: Software Project, 7 cp
- 521283S: Big Data Processing and Applications, 5 cp
- 521158S: Natural Language Processing and Text Mining, 5 cp
- 521289S: Machine Learning, 5 cp
- 521161S: Multi-Modal Data Fusion, 5 cp
- 521285S: Affective Computing, 5 cp
- 521153S: Deep Learning, 5 cp
- 521155S: Computer Security, 5 cp
- 521495A: Artificial Intelligence, 5 cp
- 521042S: Creative Design, 5 cp
- 521288S: Multiprocessor Programming, 5 cp
- 521281S: Application Specific Signal Processors, 5 cp
- 521423S: Embedded System Project, 5 cp
Advanced practical training (3 cp)

521016A: Advanced Practical Training, 3 cp

Master's Thesis (30 cp)

The Master's Thesis requires a written maturity test.

Master's Thesis / Wireless Communication

522991S: Master's Thesis in Radio Engineering, 30 cp
521011S: Maturity Test for Master's Degree, Electronics and Communications Engineering, 0 cp

Master's Thesis / Telecommunication Engineering

521998S: Master's Thesis in Telecommunication Engineering, 30 cp
521011S: Maturity Test for Master’s Degree, Electronics and Communications Engineering, 0 cp

Courses and study modules not included in degree structures

521026S: Advanced practical training, 5 cp
521907S: Fab Lab Digital Fabrication, 5 cp
521905A: Fab Lab Electronics, 5 cp
521906A: Fab Lab Programming, 5 cp
521904A: Fab Lab Project Management, 5 cp
521908S: Fab Lab Project Work, 5 cp
521006P: Glimpse into ICT, 2 cp
521015A: Practical Training, 3 cp
521018A: Practical training, 5 cp

Course descriptions

Descriptions of courses and study modules included in the degree structures

A451120: Basic and Intermediate Studies, Electrical Engineering, 150 - 170 cp

Validity: 01.08.2005 -
Form of study: Basic and Intermediate Studies
Alignment of second domestic language, written and spoken. Basic and Intermediate Studies are 124 ECTS cr (includes 2 ECTS cr Swedish and 4 ECTS cr English)

901048Y: Second Official Language (Swedish), Written Skills, 1 cp

Validity: 01.08.2014 -
Form of study: Language and Communication Studies
Type: Course
Unit: Languages and Communication
Opintokohteen kielet (E): Swedish
Leikkaavuudet (E):
   ay901048Y Second Official Language (Swedish), Written Skills (OPEN UNI) 1.0 cp

901049Y: Second Official Language (Swedish), Oral Skills, 1 cp

Validity: 01.08.2014 -
Form of study: Language and Communication Studies
Type: Course
Unit: Languages and Communication
Opintokohteen kielet (E): Swedish
Leikkaavuudet (E):
   ay901049Y Second Official Language (Swedish), Oral Skills (OPEN UNI) 1.0 cp

900081Y: Second Official Language (Finnish), Written Skills, 1 - 2 cp

Validity: 01.01.2015 -
Form of study: Language and Communication Studies
Type: Course
Unit: Languages and Communication
Opintokohteen kielet (E): Finnish

900082Y: Second Official Language (Finnish), Oral Skills, 1 - 3 cp

Validity: 01.01.2015 -
Form of study: Language and Communication Studies
Type: Course
Unit: Languages and Communication
Opintokohteen kielet (E): Finnish
Choose the minimum of 4 ects of English or German modules

902150Y: Professional English for Technology, 2 cp

Validity: 01.08.2014 -
Form of study: Language and Communication Studies
Type: Course
Unit: Languages and Communication
Grading: 1 - 5, pass, fail
Opintokohteen kielet (E): English
Leikkaavuudet (E):
  902011P-05  TE3/ Professional English for Technology  2.0 cp

Proficiency level:
CEFR B2 - C1
Status:
This course is the first English course for students in the engineering programmes in the Faculty of Technology (TTK) and Faculty of Information Technology and Electrical Engineering (TST).
Required proficiency level:
English must have been the A1 or A2 language at school or equivalent English skills acquired otherwise. If you need to take English, but lack this background, please get in touch with the Languages and Communication contact teacher for your department to discuss individual solutions.
ECTS Credits:
2 credits. The workload is 53 hours.
Language of instruction:
English
Timing:
The course takes place in the autumn semester (periods 1 and 2).
Learning outcomes:
By the end of the course, you can
- create and deliver effective presentations of a product, a company and company processes,
- apply appropriate cultural, linguistic and technical knowledge when presenting a product or company,
- evaluate your own strengths and weaknesses in English-language communication, with a view to developing appropriate skills in future.

Contents:
Scheduled as the first course of your English studies, Professional English for Technology (PET) has a strong focus on developing speaking skills necessary for working life. During PET, you will explore a product or service from your own field, and give a variety of short presentations in connection with your product or service. In addition, PET helps you to develop an awareness of your own language skills, encouraging you to develop strategies and techniques for effective learning.

Mode of delivery:
Contact teaching and independent study
Learning activities and teaching methods:
Lessons 24 hours / independent work 29 hours. Lessons include regular pair and group work in class. Independent homework activities include team work for the preparation of four short presentations, vocabulary study and other small assignments. Active participation is essential.
Target group:
Students in the engineering programmes: TTK (PO1, YMP1, KO1, TuTa1, RaKy), TST (ST2, CSE2).
Prerequisites and co-requisites:

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Recommended optional programme components:
This course is offered as the first course of your English studies.

Recommended or required reading:
Course materials will be provided by the teacher in electronic form.

Assessment methods and criteria:
The course utilises continuous assessment that is based on the learning outcomes of the course, including full and active participation in class, and the successful completion of module assignments and class presentations. Lue lisää opintosuoritusten arvostelusta yliopiston verkkosivulta.

Grading:
pass / fail

Person responsible:
Each engineering programme has its own Languages and Communication contact teacher for questions about English studies.

Working life cooperation:

- 

Other information:

- 

902142Y: Business Correspondence, 2 cp

Validity: 01.08.2014 -
Form of study: Language and Communication Studies
Type: Course
Unit: Languages and Communication
Grading: 1 - 5, pass, fail
Opintokohteen kielet (E): English

Proficiency level:
CEFR B2 - C1 (All Levels)

Status:
This course can be chosen in partial completion of the English language requirement for students in the engineering programmes in the Faculty of Technology (TTK) and Faculty of Information Technology and Electrical Engineering (TST).

Required proficiency level:
English must have been the A1 or A2 language at school or equivalent English skills acquired otherwise. If you need to take English, but lack this background, please get in touch with the Languages and Communication contact teacher for your department to discuss individual solutions.

ECTS Credits:
2 credits. The workload is 53 hours

Language of instruction:
English

Timing:
The course takes place in both autumn (periods 1 and 2) and spring (periods 3 and 4) semesters. Check the study guide for availability in your department.
Learning outcomes:
By the end of the course, you are expected to have demonstrated:
- the ability to write clear and effective business letters conveying information and details accurately,
- the ability to use an appropriate level of formality and style for business communications,
- mastery of the conventional formats and layouts of different types of business letters.

Contents:
The aim of this course is to introduce different types of business correspondence and the format used when communicating in writing. Types of correspondence include communication in business-to-business scenarios and between a business and the public.

Mode of delivery:
Self-access: the course operates within an online workspace, with online support from the teacher.

Learning activities and teaching methods:
Introductory session 2 hours / independent learning 51 hrs / optional text clinics. Assignments, instructions and course resources are available in the online course workspace. Completed assignments are submitted electronically to the teacher. The teacher provides feedback and any problems are discussed either by written electronic communication or at one of the optional text clinics.

Target group:
Students in the engineering programmes (TTK and TST)

Prerequisites and co-requisites:
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Recommended optional programme components:
This is an elective course which can be taken after 902150Y PET by students in the engineering programmes (TTK, TST and OMS).

Recommended or required reading:
Course materials are provided in an electronic form that can be downloaded.

Assessment methods and criteria:
All assignments must be completed to a standard of effective business correspondence based on the learning outcomes of the course. In addition, there is a test at the end of the course.

Grading:
Pass/Fail

Person responsible:
See contact teachers

Working life cooperation:
-

Other information:
-

902145Y: Working Life Skills, 2 cp

Form of study: Language and Communication Studies
Type: Course
Unit: Languages and Communication
Grading: 1 - 5, pass, fail
Opintokohteen kielet (E): English

Proficiency level:
1. **CEFR B2 - C1 (All Levels)**

**Status:**
This course can be chosen in partial completion of the English language requirement for students in the engineering programmes in the Faculty of Technology (TTK) and Faculty of Information Technology and Electrical Engineering (TST).

**Required proficiency level:**
English must have been the A1 or A2 language at school or equivalent English skills acquired otherwise. If you need to take English, but lack this background, please get in touch with the Languages and Communication teachers for your department to discuss individual solutions.

**ECTS Credits:**
2 ECTS credits. The workload is 53 hours.

**Language of instruction:**
English

**Timing:**
The course takes place in both autumn (periods 1 and 2) and spring (periods 3 and 4) semesters. Check the study guide for availability in your department.

**Learning outcomes:**
By the end of the course, you are expected to
1. have demonstrated a good basic vocabulary related to job applications, meetings and negotiations,
2. have demonstrated an ability to create an effective CV and cover letter for a job application,
3. be able to communicate effectively and with a reasonable degree of fluency at job interviews and in meeting and negotiation contexts.

**Contents:**
The aim of this course is to help you to develop the English language skills needed to deal with situations related to everyday working life. The course focuses on four basic areas:

i) business communication

ii) social and cultural aspects of English in working life situations,

iii) applying for a job,

iv) a general introduction to the language of meetings and negotiations.

**Mode of delivery:**
Contact teaching and independent study

**Learning activities and teaching methods:**
Lessons 26 hours / independent work 27 hours. Active participation is essential. The course includes regular pair and group work in class and independent homework activities.

**Target group:**
Students in the engineering programmes (TTK and TST).

**Prerequisites and co-requisites:**
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**Recommended optional programme components:**
This is an elective course which can be taken after 902150Y PET by students in the engineering programmes (TTK and TST).

**Recommended or required reading:**
Course materials will be provided by the teacher in electronic form.

**Assessment methods and criteria:**
The course utilises continuous assessment that is based on the learning outcomes of the course. In addition, full and active participation is required, course assignments must be completed, and students must achieve a grade of 70% in two tests during the course. Students will be asked to take an end-of-course exam if they have not otherwise demonstrated that they have achieved the learning outcomes by the end of the course.
902147Y: Academic Vocabulary for Science and Technology, 2 cp

Form of study: Language and Communication Studies
Type: Course
Unit: Languages and Communication
Grading: 1 - 5, pass, fail
Opintokohteen kielet (E): English

Proficiency level:
CEFR Level: B2-C1 (All levels)

Status:
This course can be chosen in partial completion of the English language requirement for students in the engineering programmes in the Faculty of Technology (TTK) and Faculty of Information Technology and Electrical Engineering (TST).

Required proficiency level:
English must have been the A1 or A2 language at school or equivalent English skills acquired otherwise. If you need to take English, but lack this background, please get in touch with the Languages and Communication contact teacher for your department to discuss individual solutions.

ECTS Credits:
2 ECTS credits. The workload is 53 hours.

Language of instruction:
English

Timing:
The course takes place in both autumn (periods 1 and 2) and spring (periods 3 and 4) semesters. Check the study guide for availability in your department.

Learning outcomes:
By the end of the course, you are expected to
1) explain and apply general academic / scientific vocabulary in Coxhead's Academic Word List (AWL)
2) differentiate between informal vs. formal / academic language,
3) demonstrate use of academic vocabulary in a variety of writing and communication contexts.

Contents:
The general aim of this course is to activate and broaden your basic scientific vocabulary, i.e. the core vocabulary of scientific texts, which is principally the same regardless of the field (AWL). During this process, you will become aware of the strategies which best promote your skills to learn and memorise vocabulary. The ultimate aim is to help you gain the skills to read and write academic / scientific text and to discuss related topics. To help you achieve the learning outcomes, you will work on many varied written and oral activities which focus primarily on practicing vocabulary learning strategies, word formation, and the use of the most frequent academic vocabulary (AWL sublists).

Mode of delivery:
Contact teaching and independent study

**Learning activities and teaching methods:**
Lessons 26 hours / independent work 27 hours. The independent work includes an essay; vocabulary tests; presentations, which will be given in class to small groups of students; and other homework assignments. Active participation is essential.

**Target group:**
Students in the engineering programmes (TTK and TST)

**Prerequisites and co-requisites:**
-

**Recommended optional programme components:**
This is an elective course which can be taken after 902150Y PET by students in the engineering programmes (TTK and TST).

**Recommended or required reading:**
Course materials will be provided by the teacher in electronic form.

**Assessment methods and criteria:**
Regular and active participation in the weekly sessions will be observed in continuous assessment that is based on the learning outcomes of the course. Satisfactory completion of the in-class/ homework assignments and the vocabulary tests is required.

Lue lisää [opintosuoritusten arvostelusta](https://www.yliopistonverkkopäivitysohjelma.fi/opinnot) yliopiston verkkosivulta.

**Grading:**
Pass/Fail

**Person responsible:**
See contact teachers

**Working life cooperation:**
-

**Other information:**
-

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**902149Y: Mechanics of Writing, 2 cp**

**Form of study:** Language and Communication Studies

**Type:** Course

**Unit:** Languages and Communication

**Grading:** 1 - 5, pass, fail

**Opintokohteen kielet (E):** English

**Proficiency level:**
CEFR B2-C1 (Average - Advanced)

**Status:**
This course can be chosen in partial completion of the English language requirement for students in the engineering programmes in the Faculty of Technology (TTK) and Faculty of Information Technology and Electrical Engineering (TST).

**Required proficiency level:**
English must have been the A1 or A2 language at school or equivalent English skills acquired otherwise. If you need to take English, but lack this background, please get in touch with the Languages and Communication contact teacher for your department to discuss individual solutions.

**ECTS Credits:**
2 credits. The workload is 53 hours.
Language of instruction:
English

Timing:
The course takes place in both autumn (periods 1 and 2) and spring (periods 3 and 4) semesters.

Learning outcomes:
By the end of the course, you will be able to demonstrate that
1. you can organise the structure of sentences and paragraphs for clarity and impact,
2. you can use punctuation appropriately,
3. you can make appropriate stylistic choices in academic writing.

Contents:
The purpose of this course is to help you develop essential writing skills for the production of academic and professional texts in technology.
The module covers three main topics: ordering information in sentences, punctuation and sentence style. During the module, students work independently, studying online handouts and consolidating their learning by working through online exercises.

Mode of delivery:
Web-supported independent study

Learning activities and teaching methods:
This module is completed through independent study of online resources (online handouts and exercises). An online tutor is available to answer questions and give guidance whenever necessary.

Target group:
Students in the engineering programmes (TTK and TST). Especially recommended for students with M or higher for English in matriculation exam.

Prerequisites and co-requisites:
-

Recommended optional programme components:
This is an elective course which can be taken after 902150Y PET by students in the engineering programmes (TTK and TST).

Recommended or required reading:
Course materials are available online.

Assessment methods and criteria:
The module is assessed by a final test, which can be taken on any of three test dates (approximately a month apart) each term in a classroom on the Linnanmaa campus.
Read more about assessment criteria at the University of Oulu webpage.

Grading:
Pass/Fail

Person responsible:
See contact teachers

Working life cooperation:
-

Other information:
Note! Registration for each test separately!

903024Y: Elementary Course in German 1, 3 - 4 cp

Validity: 01.08.1995 -
Form of study: Language and Communication Studies
Type: Course
Unit: Languages and Communication
Grading: 1 - 5, pass, fail
Opintokohteen kielet (E): Finnish
Leikkaavuudet (E):
ay903024Y  Elementary Course in German 1 (OPEN UNI)  4.0 cp

Proficiency level:
CEFR, A1.

Status:
The course is optional and it may be included in your faculty's Language, Cultural and Communication Studies (KieKuVi) or in other optional studies.

Required proficiency level:
Elementary Course in German 1 requires no previous German studies. This course unit is also intended for those students who have studied German before, in school or during secondary education, but a long time has passed since the previous studies.

ECTS Credits:
3 - 4 credits / 80 - 106 h of student's work

Language of instruction:
Finnish and German

Timing:
The course unit is held every semester. There are three teaching groups in the autumn semester and two in the spring.
The course lasts for one semester.

Learning outcomes:
Upon completion of the course unit the student should be able to communicate by using simple phrases in everyday language use situations both orally and in writing. The student should also know some basic information about German-speaking countries and their customs.

Contents:
The main body of the course unit consists of essential grammatical structures and vocabulary and various listening, reading, writing, discussion and pronunciation exercises. The course unit aims to help you develop your German communication skills and introduce you to the cultures of the German-speaking countries. Both everyday communication needs and professional life have been taken into account when choosing the topics to be discussed during the course unit.

Topics covered by the course unit include German-speaking countries, customs, holidays, talking about oneself, one's family and one's studies, standard professional vocabulary, one's own interests and hobbies, asking for and giving directions, making appointments, scheduling, inquiring about services, receiving services and restaurant and travelling situations.
Grammatical structures covered include verbs in the present tense, separable-prefix verbs, nominative and accusative forms of nouns, personal pronouns and possessive pronouns, accusative prepositions, conjunctions and word order in main clauses and interrogative sentences.

Mode of delivery:
Contact teaching. More detailed information in the beginning of the course.

Learning activities and teaching methods:
Contact teaching 2 times 90 min. / week , independent study
80 h of work for 3 credits
106 h of work for 4 credits

Target group:
Students of all faculties

Prerequisites and co-requisites:
Recommended optional programme components:

Recommended or required reading:
Freut mich 1 (Otava). Authors: Anja Blanco and Pauli Kudel. Chapters 1-7. Also additional study material prepared by the teacher.

Assessment methods and criteria:
Continuous assessment, 2 exams. Regular and active participation, homework assignments and tests. Students will get feedback during the course.
Read more about assessment criteria at the University of Oulu webpage.

Grading:
1 - 5 scale

Person responsible:
Kaisu Jarde and Marja Pohjola-Effe

Working life cooperation:

Other information:
Registration in WebOodi. If the registration has closed the student can sign up by contacting the teacher by e-mail.

903025Y: Elementary Course in German 2, 3 - 4 cp

Validity: 01.08.1995 -
Form of study: Language and Communication Studies
Type: Course
Unit: Languages and Communication
Grading: 1 - 5, pass, fail
Opintokohteen kielet (E): Finnish
Leikkaavuudet (E):
  ay903025Y  Elementary Course in German II (OPEN UNI)  4.0 cp

Proficiency level:
CEFR levels A1 and A2.

Status:
The course is elective and it may be included in your faculty's Language, Cultural and Communication Studies (the KieKuVi module) or in other optional studies.

Required proficiency level:
Completion of Elementary Course in German 1 or A1 proficiency level (CEFR). This course unit is also intended for those students who have studied German before, in school or during secondary education, but a long time has passed since the previous studies.

ECTS Credits:
3 - 4 ECTS credits / 80 - 106 h of student's work.

Language of instruction:
Finnish and German

Timing:
The course unit is held every semester. There are two teaching groups in the autumn semester and three in the spring. The course unit lasts for one semester.

Learning outcomes:
Upon completion of the course unit the student should be able to communicate by using simple phrases in everyday language use situations both orally and in writing. The student should also know some basic information about German-speaking countries and their customs.

Contents:
The main body of the course unit consists of essential grammatical structures and vocabulary and various listening, reading, writing, discussion and pronunciation exercises. The course unit aims to help you develop your German communication skills and introduce you to the cultures of the German-speaking countries.
Both everyday communication needs and professional life have been taken into account when choosing the topics to be discussed during the course unit. Topics covered by the course unit include shopping and talking about one’s home country.
Grammatical structures covered include present tense, perfect tense, accusative and dative, possessive pronouns, dative prepositions, the so called "dual" prepositions (accusative and dative forms), imperative form, conditional form, ordinal numerals, dates, units of time, conjunctions and word order of main clauses and subordinate clauses. The course unit allows the student to brush-up on the grammar learned during Elementary Course 1.

Mode of delivery:
Contact teaching. More detailed information in the beginning of the course.

Learning activities and teaching methods:
Contact teaching 2 times 90 min / week, independent study
80 h of work for 3 credits
106 h of work for 4 credits

Target group:
Students of all faculties

Prerequisites and co-requisites:
See Required Proficiency Level

Recommended optional programme components:
-

Recommended or required reading:
Freut mich 1 (Otava). Authors: Anja Blanco and Pauli Kudel.
Also additional study material prepared by the teacher.

Assessment methods and criteria:
Continuous assessment, 2 exams. Regular and active participation, homework assignments and tests
Read more about assessment criteria at the University of Oulu webpage.

Grading:
1 - 5 / fail

Person responsible:
Kaisu Jarde and Marja Pohjola-Effe

Working life cooperation:
-

Other information:
Registration in WebOodi. If the registration has closed the student can sign up by contacting the teacher by e-mail.
Grading: 1 - 5, pass, fail

Opintokohteen kielet (E): German

Proficiency level:
CEFR level A2/B1

Status:
The course is optional. It can be approved as a partial completion of the course unit Technical German 1. This partial completion is worth 3 ECTS credits.

Required proficiency level:
3 years of German studies during secondary education or equivalent knowledge. 903024Y Elementary Course in German 1 & 903025Y Elementary Course in German 2.

ECTS Credits:
3 - 4 ECTS credits / 80 - 106 h of students's work.

Language of instruction:
German

Timing:
The course is held in autumn term (2 groups). Please note: Intermediate Course in German 2 and Intermediate Course in German 1 can be studied in a way that first Course 2 can be taken in spring term and after that Course 1 in autumn term.

Learning outcomes:
The aim of the course is to develop the student's language skills in different areas. Upon completion of the course unit the student should be able to communicate in situations where familiar everyday topics are discussed. He/she should be able to understand relatively simple texts, express his/her opinions and manage in short dialogues. The student should be able to recognise some differences and similarities between Finnish and German-speaking cultures. He/she should be able to communicate in various everyday situations while taking into account the distinctive cultural features of the German-speaking country in question.

Contents:
Discussion exercises, grammar exercises and listening and reading comprehension exercises. Topics covered by the course include family, daily routines, free time, studies, working life and German-speaking countries and their cultures.

Mode of delivery:
Contact teaching. More detailed information in the beginning of the course.

Learning activities and teaching methods:
Contact teaching 2 times 90 min. / week, independent study
80 h of work for 3 credits
106 h of work for 4 credits

Target group:
Students of all faculties and exchange students

Prerequisites and co-requisites:
See Required proficiency requirement

Recommended optional programme components:
-

Recommended or required reading:
Material prepared by the teacher.

Assessment methods and criteria:
Regular and active participation, homework assignments and tests. Continuous assessment. Read more about assessment criteria at the University of Oulu webpage.
Grading:
Scale 1 - 5 or pass / fail
Person responsible:
Oliver Jarde
Working life cooperation:
-
Other information:
Registration in WebOodi. If the registration has closed the student can sign up by contacting the teacher by e-mail.

903030Y: Intermediate Course in German 2, 3 - 4 cp

Validity: 01.08.1995 -
Form of study: Language and Communication Studies
Type: Course
Unit: Languages and Communication
Grading: 1 - 5, pass, fail
Opintokohteen kielet (E): German

Proficiency level:
CEFR scale A2/B1
Status:
The course is optional and it may be included in your faculty's Language, Cultural and Communication Studies (KieKuVi) or in Other Studies. It may also be included as a partial 3 credit course in the Technical German 1 or 3.
Required proficiency level:
3 years of German studies during secondary education or equivalent knowledge. 903024Y Elementary Course in German 1 & 903025Y Elementary Course in German 2.
ECTS Credits:
3 - 4 ECTS credits / 80 - 106 h of work for the student.
Language of instruction:
German
Timing:
The course is held in spring term. Please note: Intermediate Course in German 2 and Intermediate Course in German 1 can be studied in a way that first Course 2 can be taken in Spring term and after that Course 1 in Autumn term.
Learning outcomes:
The aim of the course is to develop the student's language skills in different areas: improve the student's oral and written capabilities, develop his/her listening comprehension and broaden his/her vocabulary. Upon completion of the course the student should be able to manage in everyday communication situations and express and justify his/her opinions. He/she should be able to understand texts about familiar topics written in standard language and produce coherent text on topics and themes interesting to him/her.
Contents:
Grammar exercises, reading and listening comprehension exercises and writing exercises relating to work and study-related situations, small talk, politeness and German-speaking countries.
Mode of delivery:
Contact teaching. More detailed information in the beginning of the course.
Learning activities and teaching methods:
Contact teaching 2 times 90 min. / week, independent study
80 h of work for 3 credits
106 h of work for 4 credits

Target group:
Students of all faculties and exchange students.

Prerequisites and co-requisites:
See Required proficiency level

Recommended or required reading:
Material prepared by the teacher.

Assessment methods and criteria:
Regular and active participation, homework assignments and tests. Continuous assessment.
Read more about assessment criteria at the University of Oulu webpage.

Grading:
Scale 1 - 5 or pass / fail

Person responsible:
Oliver Jarde

Working life cooperation:
-

Other information:
Registration in WebOodi. If the registration has closed the student can sign up by contacting the teacher by e-mail.

Compulsory to all

521004P: Orientation to Electronics and Communications Engineering, 1 cp

Validity: 01.08.2013 -
Form of study: Basic Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Parkkila, Virpi Susanna
Opintokohteen kielet (E): Finnish

ECTS Credits:
1 ECTS

Language of instruction:
Finnish, English when needed.

Timing:
Autumn, periods 1-2.

Learning outcomes:
1. After completing this course, students are familiar with academic studies and study-related services.
2. Students know how to plan and schedule their studies based on their program curriculum.
3. Students can use the necessary information and computer systems.
Contents:
Issues related to starting the studies. Education in electrical and telecommunications engineering. The student organizations, social services offered to students (such as financial aid, sports and health services). University of Oulu and its administration.

Mode of delivery:
Contact teaching.

Learning activities and teaching methods:
Student tutoring, teacher tutoring, information sessions offered by the University, Faculty and degree program, independent work; total of 30 hours.

Target group:
1st year Electronics and Communications Engineering BSc students

Prerequisites and co-requisites:
None.

Recommended optional programme components:
None.

Recommended or required reading:
Study guide, websites, new students' folder.

Assessment methods and criteria:
Participation in information sessions as well as student and teacher tutoring. Each student is required to submit a PSP for passing the course. Read more about assessment criteria at the University of Oulu webpage. Read more about assessment criteria at the University of Oulu webpage.

Grading:
Pass/fail.

Person responsible:
Jari Hannu

Working life cooperation:
None.

Other information:

031010P: Calculus I, 5 cp

Form of study: Basic Studies
Type: Course
Unit: Applied Mathematics and Computational Mathematics
Grading: 1 - 5, pass, fail
Teachers: Ilkka Lusikka, Pauliina Uusitalo
Opintokohteen kielet (E): Finnish
Leikkaavuudet (E):

ECTS Credits:
5 ECTS credits / 135 hours of work

Language of instruction:
Finnish. The course can be completed in English by intermediate exams or by a final exam.

Timing:
Autumn semester, period 1

**Learning outcomes:**
Upon completion of the course, the student identifies concepts of vector algebra, can use vector algebra for solving problems of analytic geometry, can explain basic characteristics of elementary functions, is able to analyse the limit and the continuity of real valued functions of one variable, can solve problems associated with differential and integral calculus of real valued functions of one variable.

**Contents:**
Vector algebra and analytic geometry. Limit, continuity, differential and integral calculus and applications of real valued functions of one variable. Complex numbers.

**Mode of delivery:**
Face-to-face teaching.

**Learning activities and teaching methods:**
Lectures 28 h / Group work 22 h / Self-study 85 h.

**Target group:**
-

**Prerequisites and co-requisites:**
-

**Recommended optional programme components:**
-

**Recommended or required reading:**

**Assessment methods and criteria:**
Intermediate exams or a final exam. Read more about assessment criteria at the University of Oulu webpage.

**Grading:**
The course utilizes a numerical grading scale 0-5. In the numerical scale zero stands for a fail.

**Person responsible:**
Pauliina Uusitalo

**Working life cooperation:**
-

**Other information:**
-

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**521077P: Introduction to Electronics, 5 cp**

**Validity:** 01.08.2015 -
**Form of study:** Intermediate Studies
**Type:** Course
**Unit:** Electrical Engineering DP
**Grading:** 1 - 5, pass, fail
**Teachers:** Jari Hannu
**Opintokohteen kielet (E):** Finnish

**Leikkaavuudet (E):**
- ay521077P  Introduction to Electronics (OPEN UNI)  5.0 cp
- 521209A  Electronics Components and Materials  2.0 cp
ECTS Credits:
5 ECTS credits / 132.5 hours of work

Language of instruction:
Finnish

Timing:
The course is held in the 1st period. It is recommended to complete the course at the 1st autumn semester.

Learning outcomes:
1. Student understands the block structures of electronic devices and their signal processing paths.
2. Student can identify the interfaces of analog and digital electronics and the software operations.
3. Student is able to identify and classify electronics components and compare their properties.
4. Students can describe electric conductivity and apply the phenomenon on designing and choosing resistors
5. Student is able to estimate the difference between dielectric materials and how they affect the properties of a capacitor.
6. Student can compare properties of magnetic materials and how identify they effect on inductive components.
7. Student can identify semiconductivity and is able to list typical semiconductor components.
8. Student can classify different circuit board techniques and is able to choose proper coupling techniques.
9. Student can identify the future technologies of electronics materials.

Contents:

Mode of delivery:
Face-to-face teaching and independent work.

Learning activities and teaching methods:
The implementation methods of the course vary. The course will be arranged utilizing activating teaching methods agreed on together with the students. There will be 48 hours of guided teaching events and 84.5 hours of teaching without guidance either privately or in a group.

Target group:
First year electrical engineering students.

Prerequisites and co-requisites:
No prerequisites.

Recommended optional programme components:

Recommended or required reading:
Lecture material; Materials science and engineering: an introduction / Willam D. Callister, chapters 1, 18 and 20; Electronic components and technology / S. J. Sangwine. Chapters 1,2,3,5 and 7

Assessment methods and criteria:
This course utilizes continuous assessment. During the course, there are two intermediate exams. In addition students will make course work which are graded. The assessment of the course is based on the learning outcomes of the course. Read more about assessment criteria at the University of Oulu webpage.

**Grading:**
The course utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

**Person responsible:**
Jari Hannu

**Working life cooperation:**
No

**Other information:**
-

**521141P: Elementary Programming, 5 cp**

- **Form of study:** Basic Studies
- **Type:** Course
- **Unit:** Computer Science and Engineering DP
- **Grading:** 1 - 5, pass, fail
- **Teachers:** Mika Oja
- **Opintokohteen kielet (E):** Finnish
- **Leikkaavuudet (E):**
  - ay521141P  Elementary Programming (OPEN UNI)  5.0 cp
- **Voidaan suorittaa useasti (E):** Yes

**ECTS Credits:**
5 ECTS Cr

**Language of instruction:**
Lectures and learning material are in Finnish. The course is not available English.

**Timing:**
Fall, periods 1-2.

**Learning outcomes:**
1. Is capable of solving problems in the computer's terms
2. Understands the basic concepts of programming
3. Knows the basics of the Python programming language
4. Is able to implement programs independently
5. Is able to use the internet to find information about programming

**Contents:**
Problem solving with programming, basic concepts of programming, writing Python code.

**Mode of delivery:**
Web-based teaching + face-to-face teaching

**Learning activities and teaching methods:**
30h of exercise groups, 105h self-studying in the web.

**Target group:**
1st year students of computer science and engineering, electrical engineering, medical and wellness technology and industrial and engineering management, 2nd year students of physics, and other students of the University of Oulu

Prerequisites and co-requisites:
None.

Recommended optional programme components:
The course provides a basis for subsequent programming courses.

Recommended or required reading:
Web material in an online learning environment. Address will be announced at the beginning of the course.

Assessment methods and criteria:
The course is completed by passing all learning assignments, programming exercises and a final exercise project. Read more about assessment criteria at the University of Oulu webpage
Read more about assessment criteria at the University of Oulu webpage.

Grading:
pass/fail.

Person responsible:
Mika Oja

Working life cooperation:
-

031078P: Matrix Algebra, 5 cp

Validity: 01.08.2015 -
Form of study: Basic Studies
Type: Course
Unit: Applied Mathematics and Computational Mathematics
Grading: 1 - 5, pass, fail
Teachers: Matti Peltola
Opintokohteen kielet (E): Finnish
Leikkaavuudet (E):
  ay031078P  Matrix Algebra (OPEN UNI)  5.0 cp
  031019P  Matrix Algebra  3.5 cp

ECTS Credits:
5 ECTS credits / 135 hours of work

Language of instruction:
Finnish

Timing:
The course is held in the autumn, during period 2. It is recommended to complete the course at the 1th autumn semester.

Learning outcomes:
The student is able to apply arithmetic operations of matrices and can solve system of linear equations by matrix methods and can apply matrix factorizations to find the solution of the system of linear equations.
The student is able to recognize the vector space and understands the concepts of basis and dimension of a vector space and can analyse matrices by the parameters, vectors and vector spaces of matrices. He/She knows how to calculate determinant, eigenvalues and eigenvectors of a square matrix, and is able to diagonalize matrices and apply diagonalization to the simple problems.
Contents:

Mode of delivery:
Face-to-face teaching

Learning activities and teaching methods:
Lectures 28 h / Group work 22 h / Self-study 85 h.

Target group:
1. year students of technical sciences, mathematics and physics.

Prerequisites and co-requisites:
-

Recommended optional programme components:
-

Recommended or required reading:

Assessment methods and criteria:
The course can be completed by intermediate exams (2 exams) or by a final exam. Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course utilizes a numerical grading scale 0-5. In the numerical scale zero stands for a fail

Person responsible:
Matti Peltola

Working life cooperation:
-

Other information:
-

521109A: Electrical Measurement Principles, 5 cp

Form of study: Intermediate Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Juha Saarela
Opintokohteen kielet (E): Finnish

ECTS Credits:
5 ECTS credits / 136h

Language of instruction:
Course is lectured in Finnish. Lecture notes are available in English. Laboratory exercises and the exam can be done in English.

Timing:
Periods 1-2.

Learning outcomes:
1. is able to measure basic measurements with a multimeter,
2. is able to measure basic measurements with an oscilloscope,
3. is able to operate signal and function generators.
4. is able to estimate the validity of their measurements.

Contents:
Units of measures, standards of measures, analysis of errors, most commonly used analog and digital measuring methods, equipment and electrical safety regulations.

Mode of delivery:
Pure face-to-face teaching.

Learning activities and teaching methods:
Lectures 20h, laboratory exercises 16 h and self-study 100h.

Target group:
Course is compulsory for electrical engineering, information engineering and wellness technology students. Course is open for all students in University of Oulu.

Prerequisites and co-requisites:
None.

Recommended optional programme components:
None.

Recommended or required reading:
Course material is in English and Finnish and can be found in Optima.

Assessment methods and criteria:
Exam and passed lab exercises.
Read more about assessment criteria at the University of Oulu webpage.

Grading:
Grade is based on exam and grade is on numerical scale 1-5.

Person responsible:
Juha Saarela

Working life cooperation:
None.

Other information:
-

031075P: Calculus II, 5 cp

Validity: 01.08.2015 -
Form of study: Basic Studies
Type: Course
Unit: Applied Mathematics and Computational Mathematics
Grading: 1 - 5, pass, fail
Teachers: Pauliina Uusitalo
Opintokohteen kielet (E): Finnish
Leikkaavuudet (E):
    ay031075P     Calculus II (OPEN UNI)     5.0 cp
    031011P      Calculus II      6.0 cp
ECTS Credits:
5 ECTS credits / 135 hours of work

Language of instruction:
Finnish. The course can be completed in English by intermediate exams or by a final exam.

Timing:
Spring semester, period 3

Learning outcomes:
Upon completion of the course, the student is able to examine the convergence of series and power series of real terms, can explain the use of power series e.g. in calculating limits, is able to solve problems related to differential and integral calculus of real and vector valued functions of several variables.

Contents:
Sequences, series, power series and Fourier series of real terms. Differential and integral calculus of real and vector valued functions of several variables.

Mode of delivery:
Face-to-face teaching

Learning activities and teaching methods:
Lectures 28 h / Group work 22 h / Self-study 85 h.

Target group:
-

Prerequisites and co-requisites:
The recommended prerequisite is the completion of the course 031010P Calculus I.

Recommended optional programme components:
-

Recommended or required reading:

Assessment methods and criteria:
Intermediate exams or a final exam. Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course utilizes a numerical grading scale 0-5. In the numerical scale zero stands for a fail.

Person responsible:
Ilkka Lusikka

Working life cooperation:
-

Other information:
-

031021P: Probability and Mathematical Statistics, 5 cp

Form of study: Basic Studies
Type: Course
Unit: Applied Mathematics and Computational Mathematics
Grading: 1 - 5, pass, fail
Teachers: Jukka Kemppainen
Opintokohteen kielet (E): Finnish
**Learning outcomes:**
After completing the course the student
1. knows the key concepts of probability and the most important random variables,
2. will be able to use them in calculating probabilities and parameters of probability distributions,
3. is capable of analyzing statistical data by calculating interval and point estimates for the parameters,
4. will be able to formulate statistical hypotheses and test them,
5. knows the basics of linear regression.

**Contents:**
The key concepts of probability, random variable, parameters of probability distributions, estimation of parameters, hypothesis testing, regression analysis.

**Mode of delivery:**
Face-to-face teaching

**Learning activities and teaching methods:**
Lectures 28 h/Exercises 20 h/Self study 87 h.

**Target group:**
The students in the engineering sciences. Other students are welcome, too.

**Prerequisites and co-requisites:**
The recommended prerequisites are the course 031010P Calculus I and some parts of the course 031075P Calculus II.

**Recommended optional programme components:**
The course is an independent entity and does not require additional studies carried out at the same time.

**Recommended or required reading:**

**Assessment methods and criteria:**
Intermediate exams or a final exam.
Read more about assessment criteria at the University of Oulu webpage.

**Grading:**
The course utilizes a numerical grading scale 0-5. In the numerical scale zero stands for a fail.

**Person responsible:**
Jukka Kemppainen

**Working life cooperation:**
-
Unit: Applied Mathematics and Computational Mathematics
Grading: 1 - 5, pass, fail
Teachers: Ruotsalainen Keijo
Opintokohteen kielet (E): Finnish
Leikkaavuudet (E):
  ay031076P  Differential Equations (OPEN UNI)  5.0 cp
  800320A  Differential equations  5.0 cp
  031017P  Differential Equations  4.0 cp

ECTS Credits:
5 ECTS credits / 135 hours of work
Language of instruction:
Finnish
Timing:
The course is held in the spring, during period 4. It is recommended to complete the course at the 1th spring semester.
Learning outcomes:
The students can apply differential equations as a mathematical model. They can identify and solve various differential equations and they have knowledge on basic solvability of differential equations. The student can use the Laplace transform as a solution method.
Contents:
Ordinary differential equations of first and higher order. Laplace transform with applications to differential equations.
Mode of delivery:
Face-to-face teaching, Stack/Moodle digital learning environment
Learning activities and teaching methods:
Lectures 28 h / Group work 22 h / Self-study 85 h.
Target group:
1. year students of engineering, mathematics and physics.
Prerequisites and co-requisites:
The recommended prerequisite is the completion of the course Calculus I.
Recommended optional programme components:
-
Recommended or required reading:
Recommended literature: Kreyszig, E: Advanced Engineering Mathematics;
Assessment methods and criteria:
The course can be completed by intermediate exams (2 exams) or by a final exam. Read more about assessment criteria at the University of Oulu webpage.
Grading:
The course utilizes a numerical grading scale 0-5. In the numerical scale zero stands for a fail.

Person responsible:
Keijo Ruotsalainen
Working life cooperation:
No

521302A: Circuit Theory 1, 5 cp
**Form of study:** Intermediate Studies  
**Type:** Course  
**Unit:** Electrical Engineering DP  
**Grading:** 1 - 5, pass, fail  
**Teachers:** Rahkonen, Timo Erkki  
**Opintokohteen kielet (E):** Finnish

**ECTS Credits:**  
5

**Language of instruction:**  
Finnish. Exams can be arranged in English on demand.

**Timing:**  
Spring, period 4

**Learning outcomes:**  
After the course the student can

1. write and solve the equations describing the operation of a given electrical circuit  
2. solve the sinusoidal steady-state solution using complex phasor arithmetics  
3. solve time responses of electric circuits  
4. simplify electrical circuits e.g. using equivalent circuits  
5. simulate simple circuits and choose an appropriate circuit simulation method

**Contents:**  

**Mode of delivery:**  
Classroom.

**Learning activities and teaching methods:**  
30h lectures, 22h exercises, and a simulation exercise.

**Target group:**  
Finnish BSc students.

**Prerequisites and co-requisites:**  
Matrix algebra, complex arithmetics, differential equations.

**Recommended optional programme components:**  
Background to all analog electronics courses.

**Recommended or required reading:**  

**Assessment methods and criteria:**  
Final exam. Also the simulation exercise must be passed  
Read more about [assessment criteria](#) at the University of Oulu webpage.

**Grading:**  
1-5

**Person responsible:**  
Prof. Timo Rahkonen
Working life cooperation:
-
Other information:
-

761310A: Wave motion and optics, 5 cp

Validity: 01.08.2017 -
Form of study: Intermediate Studies
Type: Course
Unit: Field of Physics
Grading: 1 - 5, pass, fail
Teachers: Seppo Alanko
Opintokohteen kielet (E): Finnish
Leikkaavuudet (E):
  766349A  Wave motion and optics  7.0 cp
  761114P  Wave motion and optics  5.0 cp
  761114P-02  Wave motion and optics, lab. exercises  0.0 cp
  761114P-01  Wave motion and optics, lectures and exam  0.0 cp
  766329A  Wave motion and optics  6.0 cp
  761104P  Wave Motion  3.0 cp

ECTS Credits:
5 ECTS credits / 133 hours of work

Language of instruction:
Finnish. The course material and exercises are available in English.

Timing:
First spring

Learning outcomes:
The student is able to treat different types of waves by methods of general theory of wave motion. The student is also able to solve problems related to basic optics and apply her/his knowledge to teaching and research in physics.

Contents:
General principles of wave motion, sound, electromagnetic waves, propagation of light, image formation in mirrors and lenses, optical instruments, interference, Fraunhofer diffraction, diffraction grating.

Mode of delivery:
Face-to-face teaching

Learning activities and teaching methods:
Lectures 28 h, exercises 14 h, 2 laboratory exercises (3 hours/exercise), self-study 90 h

Target group:
No specific target group

Prerequisites and co-requisites:
Basic skills in mathematics.

Recommended optional programme components:
No alternative course units or course units that should be completed simultaneously

Recommended or required reading:
Assessment methods and criteria:
Two written intermediate examinations or one final examination

Grading:
Numerical grading scale 0 – 5, where 0 is fail

Person responsible:
Seppo Alanko

Working life cooperation:
No work placement period

Other information:
Includes parts:
761310A-01 Wave motion and optics, lectures and exam
761310A-02 Wave motion and optics, lab. exercises

521301A: Digital Techniques 1, 8 cp

Validity: 01.08.2015 -
Form of study: Intermediate Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Jukka Lahti

Opintokohteen kielet (E): Finnish
Leikkaavuudet (E):
  521412A-02 Digital Techniques 1, Exercise Work 0.0 cp
  521412A Digital Techniques 1 6.0 cp
  521412A-01 Digital Techniques, Exam 0.0 cp

ECTS Credits:
8
Language of instruction:
Finnish
Timing:
Periods 3-4

Learning outcomes:
1. After the course, students are able to ably binary number system and Boolean algebra in the form of switching algebra to the design and functional analyze of simple digital circuits.
2. In addition, they are also able to use in their designs graphical symbols specified in the dependency notation standard (SFS4612 ja IEEE/ANSI Std.91-1991) and different descriptions of function and structure of state machines.
3. Based on this knowledge, students are able to implement and analyze digital devices consisting of ordinary simple digital components.
4. After having assimilated the basic knowledge of digital technique, students are able to understand also the function and structure of micro controllers and micro processors.

Contents:
The principles of digital devices, Boolean algebra, numeral systems, operating principle, analysis and synthesis of combinational logic, flip-flops, operating principle, analysis and synthesis of sequential logic
(state machines), physical characteristics of CMOS technology, registers and register transfers, computer memory, instruction set architecture, computer design basics, interfaces and data transmission.

**Mode of delivery:**
Classroom

**Learning activities and teaching methods:**
Fundamentals of digital techniques: Lessons 32h, independent work (homework assignments) 106h, teaching period 3
Fundamentals of computer engineering: Lessons 8h, independent work (homework assignment) 47h, teaching period 3
Project work: Independent work 55h, teaching period 4

**Target group:**
Primarily 1st year electrical engineering and computer science and engineering BSc students. The course can be taken by the students of the university of Oulu.

**Prerequisites and co-requisites:**
- 

**Recommended optional programme components:**
The course is an independent entity and does not require additional studies carried out at the same time.

**Recommended or required reading:**
Textbook: Mano: Logic and Computer Design Fundamentals, MIT OpenCourseWare and excise literature.

**Assessment methods and criteria:**
Homework assignment and project work.
Read more about assessment criteria at the University of Oulu webpage.

**Grading:**
Pass/fail

**Person responsible:**
Jukka Lahti

**Working life cooperation:**
No

**Other information:**
- 

031077P: Complex analysis, 5 cp

**Validity:** 01.08.2015 -

**Form of study:** Basic Studies

**Type:** Course

**Unit:** Applied Mathematics and Computational Mathematics

**Grading:** 1 - 5, pass, fail

**Teachers:** Jukka Kemppainen

**Opintokohteen kielet (E):** Finnish

**Leikkaavuudet (E):**
  ay031077P     Complex analysis (OPEN UNI) 5.0 cp
  031018P     Complex Analysis 4.0 cp

**ECTS Credits:**
5 ECTS credits / 135 hours of work

**Language of instruction:**
Finnish

**Timing:**
Fall semester, period 1.

**Learning outcomes:**
After completing the course the student
1. is able to calculate the derivative and the integral of functions of complex variable,
2. understands the concept of analyticity
3. is capable of calculating the contour integrals and using the theory of residues for computing the line integrals, will be able to apply the techniques of complex analysis to simple problems in signal processing.

**Contents:**
Complex numbers and functions, complex derivative and analyticity, complex series, Cauchy's integral theorem, Laurent and Taylor expansions, theory of residues, applications to signal analysis.

**Mode of delivery:**
Face-to-face teaching, Stack(web-based too) exercises.

**Learning activities and teaching methods:**
Lectures 28 h/Exercises 14 h/Self study 93 h.

**Target group:**
The students in the engineering sciences. The other students are welcome, too.

**Prerequisites and co-requisites:**
The recommended prerequisite is the completion of the courses Calculus I and II, Differential Equations.

**Recommended optional programme components:**
The course is an independent entity and does not require additional studies carried out at the same time

**Recommended or required reading:**
The lecture notes

**Assessment methods and criteria:**
Intermediate exams or a final exam. Read more about [assessment criteria](#) at the University of Oulu webpage.

**Grading:**
The course utilizes a numerical grading scale 0-5. In the numerical scale zero stands for a fail.

**Person responsible:**
Jukka Kemppainen

**Working life cooperation:**
- 

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**521104P: Introduction to Material Physics, 5 cp**

**Form of study:** Basic Studies

**Type:** Course

**Unit:** Electrical Engineering DP

**Grading:** 1 - 5, pass, fail

**Teachers:** Juha Hagberg

**Opintokohteen kielet (E):** Finnish

**ECTS Credits:**
5 ECTS credits / 132.5 hours of work

**Language of instruction:**
Finnish.

**Timing:**
Autumn semester period 1

**Learning outcomes:**
1. is able to explain the principal solid state crystal structures
2. can explain how propagating waves and electrons in a crystal lattice can be presented
3. can explain the free electron model of metals and the formation of the energy band structure in crystals and their significance to the electrical properties of materials
4. is able to explain the basic phenomena related to semiconductors and is able to calculate the charge carrier concentrations in them

**Contents:**

**Mode of delivery:**
Will be notified in the beginning of lectures

**Learning activities and teaching methods:**
Will be notified in the beginning of lectures

**Target group:**
Second year electrical engineering students

**Prerequisites and co-requisites:**
Basic physics and mathematics.

**Recommended optional programme components:**
Basic course for 521071A Principles of Semiconductor Devices.

**Recommended or required reading:**

**Assessment methods and criteria:**
Will be notified in the beginning of lectures.
Read more about assessment criteria at the University of Oulu webpage.

**Grading:**
Will be notified in the beginning of lectures. Read more about assessment criteria at the University of Oulu webpage.

**Person responsible:**
Juha Hagberg

**Working life cooperation:**
No

**Other information:**
- 

**031080A: Signal Analysis, 5 cp**

**Validity:** 01.08.2015 -

**Form of study:** Intermediate Studies
Type: Course
Unit: Applied Mathematics and Computational Mathematics
Grading: 1 - 5, pass, fail
Teachers: Kotila, Vesa Iisakki
Opintokohteen kielet (E): Finnish
Leikkaavuudet (E):
031050A  Signal Analysis  4.0 cp

ECTS Credits:
5 ECTS credits / 135 hours of work

Language of instruction:
Finnish.
The course can be completed in English by partial exams or by a final exam. The material is available in English.

Timing:
The course is held in the autumn semester, during period II. It is recommended to complete the course at the 2nd autumn semester.

Learning outcomes:
Upon completion of the course, the student:
- is able to calculate the energy, the power, the convolution and the frequency spectrum of discrete and analog, periodic and non-periodic deterministic signals
- is able to calculate the spectrum of a sampled signal
- is able to calculate the Hilbert transform and the complex envelope of a signal
- is able to study the stationarity, the mutual dependence and the frequency content of random signals by means of the auto- and cross-correlation functions, and the power- and cross-power spectral densities
- is able to study the effect of an LTI system on a signal

Contents:

Mode of delivery:
Blended teaching.

Learning activities and teaching methods:
Lectures 28 h / Exercises 14 h / Self-study privately or in a group 93 h. The independent work includes individual STACK-assignments as online work.

Target group:
-

Prerequisites and co-requisites:
The recommended prerequisite is the completion of the courses 031078P Matrix Algebra, 031021P Probability and Mathematical Statistics and 031077P Complex Analysis.

Recommended optional programme components:
The course is an independent entity and does not require additional studies carried out at the same time.

Recommended or required reading:

Assessment methods and criteria:
The course is completed with two partial exams or a final exam. STACK-assignments given during the course are part of the assessment with partial exams. The assessment of the course is based on the learning outcomes of the course. Read more about assessment criteria at the University of Oulu webpage.

**Grading:**
The course utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

**Person responsible:**
Vesa Kotila

**Working life cooperation:**
-

**521303A: Circuit Theory 2, 5 cp**

**Validity:** 01.08.2015 -
**Form of study:** Intermediate Studies
**Type:** Course
**Unit:** Electrical Engineering DP
**Grading:** 1 - 5, pass, fail
**Teachers:** Rahkonen, Timo Erkki

**Opintokohteen kielet (E):** Finnish
**Leikkaavuudet (E):**
521306A  Circuit Theory 2  4.0 cp

**ECTS Credits:**
5
**Language of instruction:**
Finnish
**Timing:**
Autumn, period 2

**Learning outcomes:**
After the course the student can:
1. use Laplace transform for solving time and frequency response of electric circuits;
2. derive continuous-time transfer functions;
3. solve their poles and zeros and understand the meaning of those;
4. draw the pole-zero map and Bode plots of any given transfer function;
5. construct 2-port parameter models of a given circuit

**Contents:**
Use of Laplace transform in network analysis. Properties of network functions, poles and zeros, Boden magnitude and phase plots. 2-port parameter models.

**Mode of delivery:**
Classroom

**Learning activities and teaching methods:**
30h lectures, 22 h exercises, and simulation excercises.

**Target group:**
Finnish BSc students

**Prerequisites and co-requisites:**
Basics of circuit theory, differential equations.

**Recommended optional programme components:**
Continuation for Circuit theory 1. Needed in most analog electronics courses.

**Recommended or required reading:**

**Assessment methods and criteria:**
Final exam. Also the simulation exercise must be passed.
Read more about [assessment criteria](#) at the University of Oulu webpage.

**Grading:**
Numerical 1-5

**Person responsible:**
Prof. Timo Rahkonen

**Working life cooperation:**
-

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**521287A: Introduction to Computer Systems, 5 cp**

**Validity:** 01.08.2016 -

**Form of study:** Intermediate Studies

**Type:** Course

**Unit:** Computer Science and Engineering DP

**Grading:** 1 - 5, pass, fail

**Teachers:** Teemu Leppänen

**Opintokohteen kielet (E):** Finnish

**Leikkaavuudet (E):**
- ay521287A  Introduction to Computer Systems (OPEN UNI)   5.0 cp
- 521142A  Embedded Systems Programming   5.0 cp

**ECTS Credits:**
5 ECTS cr

**Language of instruction:**
Lecturing in Finnish, course and exercise material available in English.

**Timing:**
Autumn, periods 1-2.

**Learning outcomes:**
Upon completing the course, the student understands the basics of computer architecture and CPU operation.
Student knows number systems and data representations in computer.
Student is familiar of I/O operation with peripheral devices.
Student is able to implement small programs with the C programming language for workstations and embedded systems.
Student recognizes how embedded systems programming is different from programming general-purpose computers.

**Contents:**
Overview of computer architecture and CPU, data types and memory management, interrupts, registers and I/O, general computer and embedded systems programming, basics of the C programming language.

**Mode of delivery:**
Web-based teaching + face-to-face teaching.
Learning activities and teaching methods:
Lectures (16h), course exercises (10-20h), laboratory exercise (3h) and course project in a group.

Target group:
Students of the University of Oulu

Prerequisites and co-requisites:
Elementary programming 521141P

Recommended optional programme components:
The course is an independent entity and does not require additional studies carried out at the same time.

Recommended or required reading:
Lecture notes and exercise material are available in the course website. For English speaking students, either of the following material may be useful:

Assessment methods and criteria:
The assessment criteria is based on the learning outcomes of the course. Students complete the course exercises, participate to the laboratory exercise and complete the course project in a group. Assessment is based on the exercises and the course project. More detailed information on assessment is published in the lecture material.
Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course unit utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible:
Teemu Leppänen

Working life cooperation:
Visiting lectures with experts from local industry are possible.

Other information:
This course replaces the course 521142A Embedded systems programming.

521337A: Digital Filters, 5 cp

Form of study: Intermediate Studies
Type: Course
Unit: Computer Science and Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Olli Silven
Opintokohteen kielet (E): Finnish

ECTS Credits:
5 ECTS cr

Language of instruction:
Finnish, English study material available

Timing:
Spring, period 3.
Learning outcomes:
1. Student is able to specify and design respective frequency selective FIR and IIR filters using the most common methods.

2. Student is able to solve for the impulse and frequency responses of FIR and IIR filters given as difference equations, transfer functions, or realization diagrams, and can present analyses of the aliasing and imaging effects based on the responses of the filters.

3. Student is able to explain the impacts of finite word length in filter design.

4. Student has the necessary basic skills to use signal processing tools available in Matlab environment and to judge the results.

Contents:

Mode of delivery:
Face-to-face teaching (Lectures), independent work, group work

Learning activities and teaching methods:
Lectures and exercises 50 h. The design exercises familiarize the students with the methods of digital signal processing using the Matlab software package. The rest as independent work.

Target group:
Computer Science and Engineering students and other Students of the University of Oulu.

Prerequisites and co-requisites:
031077P Complex Analysis, 031080A Signal Analysis

Recommended optional programme components:
The course is an independent entity and does not require additional studies carried out at the same time.

Recommended or required reading:

Assessment methods and criteria:
The course can be passed either with week exams or a final exam. In addition, the exercises need to be returned and accepted.
Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course unit utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible:
Olli Silven

Working life cooperation:
None.

521071A: Principles of Semiconductor Devices, 5 cp

Validity: 01.08.2015 -
Form of study: Intermediate Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Juha Hagberg, Jani Peräntie

Opintokohteen kielet (E): Finnish
Leikkaavuudet (E):
  521205A  Principles of Semiconductor Devices  4.5 cp

ECTS Credits:
5 ECTS credits / 132.5 hours of work

Language of instruction:
Finnish

Timing:
Spring semester period 3

Learning outcomes:
1. will be able to explain physical phenomena in semiconductor materials and junctions; describe main
types and characteristics of semiconductor diodes and transistors
2. will be able to explain physical principles of operation and to estimate ideal characteristics of the
devices

Contents:
Switching devices.

Mode of delivery:
Will be notified in the beginning of lectures.

Learning activities and teaching methods:
Will be notified in the beginning of lectures.

Target group:
Second year electrical engineering students

Prerequisites and co-requisites:
521104P Introduction to materials physics.

Recommended optional programme components:
The course is an independent entity and does not require additional studies carried out at the same time.

Recommended or required reading:
2000 (chapters 5 - 8, 11).

Assessment methods and criteria:
Will be notified in the beginning of lectures.
Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible:
Juha Hagberg

Working life cooperation:
No.

Other information:

521431A: Principles of Electronics Design, 5 cp

Form of study: Intermediate Studies
**Type:** Course  
**Unit:** Electrical Engineering DP  
**Grading:** 1 - 5, pass, fail  
**Teachers:** Juha Kostamovaara  
**Opintokohteen kielet (E):** Finnish

**ECTS Credits:**  
5

**Language of instruction:**  
Finnish.

**Timing:**  
Spring, period 3

**Learning outcomes:**  
1. should be able to analyze and design such electronic building blocks as rectifiers, clamping circuits, amplifiers and CMOS logic elements using diodes, operational amplifiers and MOS and bipolar junction transistors.

**Contents:**  
Analogue and digital circuits, basic amplifier related concepts, diodes and diode circuits, single stage bipolar and MOS transistor amplifiers, small signal modeling and analyzing ac properties of amplifiers, internal structures of digital circuits (mainly CMOS), MOS/CMOS switch, operational amplifier.

**Mode of delivery:**  
Face-to-face teaching

**Learning activities and teaching methods:**  
Lectures 30 h and exercises 20 h.

**Target group:**  
Students of Electrical engineering. Other students of the University of Oulu may also participate.

**Prerequisites and co-requisites:**  
Circuit Theory I

**Recommended optional programme components:**  
Recommended course Principles of Semiconductor Devices.

**Recommended or required reading:**  

**Assessment methods and criteria:**  
Final or 2 mid-term exams.  
Read more about assessment criteria at the University of Oulu webpage.

**Grading:**  
Numerical grading scale 1-5.

**Person responsible:**  
Juha Kostamovaara

**Working life cooperation:**  
-

761312A: Electromagnetism 2, 5 cp
Validity: 01.08.2017 - 
Form of study: Intermediate Studies 
Type: Course 
Unit: Field of Physics 
Grading: 1 - 5, pass, fail 
Teachers: Anita Aikio 
Opintokohteen kielet (E): Finnish 
Leikkaavuudet (E): 
  766319A  Electromagnetism  7.0 cp 

ECTS Credits: 
5 ECTS credits / 133 hours of work 

Language of instruction: 
Finnish 

Timing: 
Second spring term 

Learning outcomes: 
The student will be able to derive the individual results like electric fields produced by charge distributions, magnetic field by current systems and solve problems related to electromagnetic induction. The student can derive the wave equation for electromagnetic waves. 

Contents: 
The foundations of the electromagnetic field theory. Exact contents to be specified later. 

Mode of delivery: 
face-to-face teaching 

Grading: 
Numerical grading scale 0 – 5, where 0 = fail 

Person responsible: 
anita aikio 

521330A: Telecommunication Engineering, 5 cp 

Validity: 01.08.2015 - 
Form of study: Intermediate Studies 
Type: Course 
Unit: Electrical Engineering DP 
Grading: 1 - 5, pass, fail 
Teachers: Kari Heikki Antero Kärkkäinen 
Opintokohteen kielet (E): Finnish 
Leikkaavuudet (E): 
  521357A  Telecommunication Engineering I  3.0 cp 
  521361A  Telecommunication Engineering II  3.0 cp 

ECTS Credits: 
5 ECTS, equals 125 hours of student's work 

Language of instruction: 
Finnish. The course can be completed in other languages e.g. in English as a book examination of specified pages of course book.
Timing:
The course is lectured on period 4. Recommended for second study year.

Learning outcomes:
1. can tell and explain the essential blocks and their operation in time & frequency domains for frequently used analog and digital carrier and pulse modulation methods.
2. understands essential differences both between linear and non-linear modulations, and between coherenr and non-coherent modulations.
3. understands in which system applications each analog or digital modulation is typically used.
4. can tell limitations on system performance caused by noise interference and various transmission channels, and can propose methods to suppress interference both in analog and digital transmission.
5. can perform system analysis, and can calculate performances of analog and digital modulations based on simple assumptions regarding channel models.
6. can compare modulations from the standpoints of resource use (transmitted power and bandwidth needed) and implementation complexity.
7. understands the meanings of various equalizing, diversity and coding methods from the standpoint of improvement for digital transmission reliability.
8. understands various standards and specifications of new digital transmission systems.
9. can apply gained knowledge in working life to design of systems and their sub-system units, and can also perform computer simulations.
10. understands the principles of information theory, source coding and error-control coding, and masters various most commonly used coding methods.

Contents:

Mode of delivery:
Face-to-face teaching.

Learning activities and teaching methods:
Face-to-face teaching 52 h. No separate times for class-exercises. Exercises are integrated as part of face-to-face teaching event. Self-study 73 h. Total 125 h.

Target group:
Second year B.Sc.(Tech.) students both in electronics and telecommunication engineering, and in computer science and engineering (CSE) degree programmes.

Prerequisites and co-requisites:
031080A Signal analysis course.

Recommended optional programme components:
No connections to other courses.

Recommended or required reading:
Lecture slides in Finnish are stored into digital learning environment (Optima / Moodle). The course and lecture slides are based on the book: R.E. Ziemer & W.H. Tranter: Principles of Communications: Systems, Modulation and Noise, 7th edition, 2015, John Wiley & Sons, Partially chapters: Ch 1 (ss. 1-16), Ch 3 (112-
Assessment methods and criteria:
Course can be passed either with four mid-term exams, or with final exam.

Grading:
The course utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail. Read more about assessment criteria at the University of Oulu webpage.

Person responsible:
Kari Kärkkäinen

Working life cooperation:
No

Other information:
This course replaces the following candidate level courses: 521357A Telecommunication Engineering I (3 ECTS) and 521361A Telecommunication Engineering II (3 ECTS).

521432A: Electronics Design I, 5 cp

Form of study: Intermediate Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Kari Määttä
Opintokohteen kielet (E): Finnish

ECTS Credits:
5

Language of instruction:
Finnish.

Timing:
Spring, period 4.

Learning outcomes:
1. should be able to recount the principles covering the design of multistage amplifiers
2. should be able to analyze and set the frequency response of a transistor amplifier
3. should be able to make use of feedback to improve the properties of an amplifier in the desired manner
4. should be able to analyze the stability of a given degree of feedback amplification and to dimension an amplifier correctly to ensure stability
5. should be able to describe the principles governing the design of power amplifiers
6. should be able to make widespread use of operational amplifiers for realizing electronic circuits and to take account of the limitations imposed by the non-idealities inherent in operational amplifiers
7. should be able to design low-frequency oscillators, to explain the operating principles of radio frequency oscillators and tuned amplifiers

Contents:
Frequency response of a transistor amplifier, differential amplifier, feedback, power amplifiers, oscillators and tuned amplifiers, non-idealities of an operational amplifier, applications of operational amplifiers.

**Mode of delivery:**
Face-to-face teaching

**Learning activities and teaching methods:**
Lectures 40 h and exercises 20 h.

**Target group:**
Students of Electrical engineering. Other students of the University of Oulu may also participate.

**Prerequisites and co-requisites:**
Principles of electronic design

**Recommended optional programme components:**
This course is required when participating in Laboratory Exercises on Analogue Electronics.

**Recommended or required reading:**

**Assessment methods and criteria:**
Final or 2 mid-term exams.
Read more about assessment criteria at the University of Oulu webpage.

**Grading:**
Numerical grading scale 1-5.

**Person responsible:**
Juha Kostamovaara

**Working life cooperation:**
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**Other information:**
- 

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**521329A: Hands-on Course in Wireless Communication, 5 cp**

**Validity:** 01.08.2015 -

**Form of study:** Intermediate Studies

**Type:** Course

**Unit:** Electrical Engineering DP

**Grading:** 1 - 5, pass, fail

**Teachers:** Kari Heikki Antero Kärkkäinen

**Opintokohteen kielet (E):** Finnish

**Leikkaavuudet (E):**

521316A Broadband Communications Systems 4.0 cp

**ECTS Credits:**
5 ECTS, equals 125 hours of student's work

**Language of instruction:**
Finnish

**Timing:**
The course is organized in the autumn semester during 1. period. It is recommended to complete the course at the 3rd year autumn semester.

**Learning outcomes:**
After completing course a student
1. is acquainted with the principles of universal software radio peripheral (USRP) technologies and their implementation. That is obtained with the aid of small laboratory exercise work tasks which require understanding theories of basic analog and digital carrier modulation methods.
2. understands the idea of complex-valued I&Q vector-signals, which exist behind software radios and measurement techniques.
3. has learned how to use universal software radio peripheral transceivers, and how to observe them in laboratory environment. Student also understands how to control these FGPA-based (field-programmable gate array) devices with the aid of control software platforms (e.g. Matlab-Simulink, LabVIEW, GNU Radio) and understands their limitations.
4. implemented and tested various basic modulation methods both in radio channel and coaxial cable channel, and has made real observations and measurements in time-frequency domain using USRP control software.
5. has learned to find and deduct radio signal spectras and time waveforms with the aid of time-frequency analysis.
6. can test and model in laboratory environment during course and later in work life various problems and solutions dealing with wireless communication before construction of a prototype device.

**Contents:**
Students are introduced to the wireless communication systems and their phenomena with the aid of guided laboratory exercises. The course utilizes National Instruments USRP-2900 universal software radio peripheral tranceiver. Also other radio platforms and IoT equipments may be utilized.

**Mode of delivery:**
Face-to-face teaching and guided laboratory exercises in a class. Self-studying at home between work themes. Writing of exercise work report for each conducted work task.

**Learning activities and teaching methods:**
Course consist of small wireless communication tasks using various analog and digital carrier modulations. Total number of exercise works is 7. The course utilizes mainly National Instruments USRP-2900 universal software radio peripheral tranceiver which is controlled via laptop computer’s USB connection. Transmission and receiving of I&Q signals are controlled with Matlab. Students are required to have competent laptop with Matlab-Simulink campus licence. If necessary, students have to participate in short briefing lectures, in addition to get instructions for each exercise work. Exercises are done by a group of 2 students. Results are summarized in a written report for each task according to given instructions. Students have to return report two weeks after each work session.

Course contains 14 hours lectures for work instructions and 28 hours of measurement work. In addition, students perform 83 hours of self-study and reporting at home. Total 125 hours.

**Target group:**
Third year bachelor level electrical engineering students.

**Prerequisites and co-requisites:**
031080A Signal analysis and 521330A Telecommunication engineering

**Recommended optional programme components:**
The course is an independent entity and does not require additional studies carried out at the same time.

**Recommended or required reading:**
No course book. Lecture slides, and problem assignments together with work instruction are given during the course. Materials will be placed into TTK-Optima environment. In addition, some NI USRP-2900 related material will be placed into Optima. Some materials and links can be found also from the Noppa page: [https://noppa.oulu.fi/noppa/kurssi/521329a/etusivu](https://noppa.oulu.fi/noppa/kurssi/521329a/etusivu)

**Assessment methods and criteria:**
All students of a group have to participate in introductory face-to-face teaching and briefing lecture, and will prepare a final report according teacher's instructions. Before student's mandatory absence, a student has to negotiate that with a teacher. Participation in all introductory lectures and laboratory exercises is mandatory for all members of a group. Presence of each student is monitored by a teacher. In addition, final report has to be in form required by a course teacher, and the content has to be satisfying from acceptance standpoint. Course does not contain final exam.

Read more about assessment criteria at the University of Oulu webpage.

**Grading:**
For each exercise work grading is done with the numbers 0...5. Grade 0 is interpreted as failed. Each work must have at least grade 1. Final grade is an average of sub-tasks with standard rounding technique.

**Person responsible:**
Kari Kärkkäinen

**Working life cooperation:**
No

**Other information:**
-

**521384A: Basics in Radio Engineering, 5 cp**

**Form of study:** Intermediate Studies

**Type:** Course

**Unit:** Electrical Engineering DP

**Grading:** 1 - 5, pass, fail

**Teachers:** Aarno Pärssinen, Risto Vuohtoniemi

**Opintokohteen kielet (E):** Finnish

**ECTS Credits:**
5

**Language of instruction:**
Finnish

**Timing:**
Autumn, 1st period

**Learning outcomes:**
1. can define what radio engineering is and list its separate areas and applications from FM-radio to 5G systems.

2. understands the meaning of Maxwell's equations and can solve the propagation of radio waves in a homogeneous medium.

3. can solve EM-fields at an interface of two lossless media.

4. knows main properties of most common transmission line types and can solve EM-fields for coaxial lines and rectangular waveguides.

5. can utilize the methods based on the Smith chart for the impedance matching of microwave circuits and antennas.

6. understands the meaning of Y-, Z-, and S-matrix and can use S-parameters for solving characteristics of microwave circuits.
7. can describe the operation of passive transmission line devices, resonators, filters and circuits based on the semiconductor devices.

8. knows the terms to describe antenna characteristics and can define radiation patterns of simple antennas and antenna arrays.

9. knows different propagation phenomena and can evaluate, which phenomena are relevant in different radio systems in different frequency bands.

10. can describe the structure of a typical radio system and can calculate the S/N-ratio link budget for a radio system on a free-space radio link.

Contents:

Mode of delivery:
Face-to-face teaching.

Learning activities and teaching methods:
Lectures 26 h and exercises 16 h including graded exercise problems.

Target group:
3rd year bachelor’s degree students.

Prerequisites and co-requisites:
Elementary knowledge of the electromagnetic theory.

Recommended optional programme components:
-

Recommended or required reading:
In Finnish: Antti Räisänen & Arto Lehto: Radiotekniikan perusteet. Otatieto, 2011; also older versions of the book can be used as a course book.

Assessment methods and criteria:
The course is passed with a final examination.
Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course unit utilizes a numerical grading scale 1-5.

Person responsible:
Risto Vuotioniemi, Aarno Pärssinen.

Working life cooperation:
No

Other information:
-

521241A: Optical systems, 5 cp
Validity: 01.08.2017 -
Form of study: Intermediate Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Anssi Mäkynen
Opintokohteen kielet (E): Finnish

ECTS Credits:
5 ECTS cr

Language of instruction:
Lectures are in Finnish. All written material is also in English. In guided labworks the assistant can English.

Timing:
Period 1.

Learning outcomes:
1. is capable of explaining the basic facts of geometrical and physical optics
2. is able of explaining the operating principles of simple optical components and instruments
3. is able to describe an optical system as a principal point representation
4. is able to trace the most important paraxial rays through the system
5. is able to explain the properties of a laser beam
6. is able to estimate the radiometric properties and resolving power of an ideal optical system
7. is capable of recognizing and explaining the difference between imaging, non-imaging and laseroptics as well as able to conclude from which of these viewpoints he/she should approach a given design task
8. is capable of designing and optimizing simple imaging and non-imaging lens systems as well as optics for laser beam modification using optical design software tools and 3D printing.

Contents:
Basics of geometrical and physical optics, optical components and instruments. Optical design software tools.

Mode of delivery:
Face-to-face teaching.

Learning activities and teaching methods:
Lectures 24 exercises 12 h and self-study 100 h.

Target group:
Course is mandatory for Electrical Engineering students. All students of the University of Oulu can attend the course.

Prerequisites and co-requisites:
None.

Recommended optional programme components:
-

Recommended or required reading:
Material in Optima

Assessment methods and criteria:
Final exam and passed lab exercises.
Read more about assessment criteria at the University of Oulu webpage.

Grading:
1 - 5

Person responsible:
Anssi Mäkynen
Anssi Mäkynen

Working life cooperation:
-

Other information:
-

521404A: Digital Techniques 2, 5 cp

**Form of study:** Intermediate Studies  
**Type:** Course  
**Unit:** Electrical Engineering DP  
**Grading:** 1 - 5, pass, fail  
**Teachers:** Jukka Lahti  
**Opintokohteen kielet (E):** Finnish

**ECTS Credits:**  
5

**Language of instruction:**  
In Finnish. Exams can be arranged in English on demand.

**Timing:**  
Autumn, period 2

**Learning outcomes:**
1. knows the common architectures of synchronous digital logic circuits, and the building blocks they consist of, and can design digital circuits that realize complex data and signal processing functions.  
2. knows most common combinational and sequential logic based building blocks, and can use them to design and realize complex digital circuits.  
3. knows digital logic design methods, such as use of hardware description languages, functional verification using simulation, realization of logic with a logic synthesis program, and functional and timing verification of gate-level models.

**Contents:**

**Mode of delivery:**  
Classroom

**Learning activities and teaching methods:**
Lectures 24h/ exercises 30h (group work)/independent work  84h.

**Target group:**  
Primarily electrical and computer science and engineering students. Also other student of University of Oulu can take the course.

**Prerequisites and co-requisites:**
Digital techniques 1

**Recommended optional programme components:**
No

**Recommended or required reading:**
Lecture textbook (in finnish) and literature announced during course.

**Assessment methods and criteria:**
Final exam and a design exercise, or weekly assignments consisting of theoretical and design exercises. Read more about assessment criteria at the University of Oulu webpage.

Grading:
1-5, The grade is the average of the exam and the design exercise, or the grade of the weekly assignments.

Person responsible:
Jukka Lahti

Working life cooperation:
No

Other information:

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521070A: Introduction to Microfabrication Techniques, 5 cp

Validity: 01.08.2015 -
Form of study: Intermediate Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Teirikangas, Merja Elina
Opintokohteen kielet (E): Finnish
Leikkaavuudet (E):

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Description</th>
<th>Credits</th>
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<tr>
<td>521218A</td>
<td>Introduction to Microelectronics and Micromechanics</td>
<td>4.0 cp</td>
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<tr>
<td>521218A-02</td>
<td>Introduction to Microelectronics and Micromechanics, demonstration</td>
<td>0.0 cp</td>
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<tr>
<td>521218A-03</td>
<td>Introduction to Microelectronics and Micromechanics, exercise</td>
<td>0.0 cp</td>
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<tr>
<td>521218A-01</td>
<td>Introduction to microelectronics and micromechanics, exam</td>
<td>0.0 cp</td>
</tr>
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</table>

ECTS Credits:
5

Language of instruction:
Finnish

Timing:
2nd period

Learning outcomes:
1. Can present the process of source materials used to manufacture micro- and nanoelectronics/mechanics and analyse the required material properties depending of the application

2. Can explain the fabrication methods and discuss the characteristic features of each fabrication method, including their utilisation and restrictions.

3. Is capable of designing a fabrication process for a simple microelectronics application and is able to indentify the process steps also in complex application.

Contents:

Mode of delivery:
Face-to-face teaching
Learning activities and teaching methods:
Lectures (20 hours) and exercises (10 +10).

Target group:
Electrical engineering bachelor degree students.

Prerequisites and co-requisites:
Course content of 521104P Introduction to Materials Physics and 521071A Principles of Semiconductor Devices.

Recommended optional programme components:
-

Recommended or required reading:
Lecture notes, Franssila Sami: Introduction to Microfabrication

Assessment methods and criteria:
Final written exam and passes laboratory exercises.

Grading:
Numerical grading 1-5.

Person responsible:
Merja Teirikangas

Working life cooperation:
No

521307A: Laboratory Exercises on Analogue Electronics, 5 cp

Validity: 01.08.2015 -
Form of study: Intermediate Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Kari Määttä

Opintokohteen kielet (E): Finnish
Leikkaavuudet (E):
- 521316A Broadband Communications Systems 4.0 cp
- 521433A Laboratory Exercises on Analogue Electronics 3.0 cp

ECTS Credits:
5

Language of instruction:
Finnish

Timing:
Autumn, periods 1-2

Learning outcomes:
1. is able to design basic electronic structural blocks and verify their functionality in a CAD simulation environment.

2. is able independently to realize and test a small-scale design object employing analogue circuit techniques.

Design exercises to deepen the understanding of the material presented in Principles of Electronics Design and Analogue Electronics I.
Contents:
Passive RC-circuits, diodes and their applications, bipolar transistor amplifiers, operational amplifiers and their applications, MOS-transistor, tuned circuit and amplifier, oscillator.

Mode of delivery:
Face-to-face teaching, partially independent work

Learning activities and teaching methods:
Independent design and simulating exercise 26 h and guided laboratory work 15 h. Group size is 1 - 2 students.

Target group:
Primarily in electrical engineering students. Other University of Oulu students can complete the course.

Prerequisites and co-requisites:
Student must participate to courses Principles of Electronics Design and Electronics Design I, or he/she must have passed these courses earlier.

Recommended optional programme components:
No

Recommended or required reading:
Lecture notes of Principles of Electronic design and Electronics design 1.

Assessment methods and criteria:
Teacher accepts student's design work and measurement results in laboratory. Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course unit utilizes verbal grading scale pass or fail

Person responsible:
Kari Määttä

Working life cooperation:
No

Other information:
-

521304A: Filters, 5 cp

Validity: 01.08.2015 -
Form of study: Intermediate Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Rahkonen, Timo Erkki
Opintokohteen kielet (E): Finnish
Leikkaavuudet (E):

ECTS Credits:
5

Language of instruction:
Finnish. Exams can be arranged in English on demand.

Timing:
Spring, period 3
Learning outcomes:
After the course the student can:
1. draw a pole-zero map for a given transfer function;
2. perform impedance and frequency scaling for component values;
3. choose an appropriate prototype filter and filter degree;
4. synthesize passive RLC filters;
5. synthesize active opamp based filters;
6. can compare various filter technologies;
7. understands the basics of scaling the dynamic range of active filters

Contents:
Filter types and prototypes, component scaling. Synthesis of active and passive filters. Sensitivity analysis and scaling of the dynamic range.

Mode of delivery:
Lectures, excercise and design exercise

Learning activities and teaching methods:
30 h lectures, 16 h exercises. A design exercise.

Target group:
Finnish electrical engineering students

Prerequisites and co-requisites:
Basics of circuit theory, Bode plots and analog design.

Recommended optional programme components:
Course Digital filters expands the topic into digital domain.

Recommended or required reading:

Assessment methods and criteria:
Circuit is examined by a final exam. Also the obligatory design exercise must be passed.
Read more about assessment criteria at the University of Oulu webpage.

Grading:
1-5

Person responsible:
Prof. Timo Rahkonen

Working life cooperation:
-

Other information:
-

521092A: Electronic Measurement Techniques, 5 cp

Validity: 01.08.2015 -
Form of study: Intermediate Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Juha Saarela
Opintokohteen kielet (E): Finnish
Leikkaavuudet (E):

521171A   Electronic Measurement Techniques   6.5 cp
ECTS Credits:
5 ECTS credits / 136 h

Language of instruction:
Course is lectured in Finnish. Lecture notes are available in English. Calculation exercises, laboratory exercises and the exam can be done in English.

Timing:
Period 4

Learning outcomes:
1. can name the electrical measurement technique terminology associated to measurement systems, sensors and buses to candidate level.
2. can plan and implement complicated measurements with oscilloscopes
3. can plan and implement basic measurements with spectrum analyzers
4. can plan and implement basic measurements with light detectors
5. can name common sources of noise and interference
6. name means to control noise and interference
7. can name methods to realize electrical quantities

Contents:
Broad view to electronic measurements.

Mode of delivery:
Pure face-to-face teaching.

Learning activities and teaching methods:
Lectures and calculation exercises 30h, laboratory exercises 16 h and self-study 90h

Target group:
Course is compulsory for electrical engineering students. Course is open for all students in University of Oulu.

Prerequisites and co-requisites:
Courses of Electrical Measurement Principles and Analogue Electronics I are recommended.

Recommended optional programme components:
The course replaces previous courses with same name, but different credits and code.

Recommended or required reading:
Course material is in English and Finnish and can be found in Optima.

Assessment methods and criteria:
Exam and passed lab exercises.
Read more about assessment criteria at the University of Oulu webpage.

Grading:
Grade is based on exam and grade is on numerical scale 1-5.

Person responsible:
Juha Saarela

Working life cooperation:
None.

Other information:

030005P: Information Skills, 1 cp

Form of study: Basic Studies
Type: Course
Unit: Faculty of Technology
Grading: 1 - 5, pass, fail
Teachers: Ursula Heinikoski
Opintokohteen kielet (E): Finnish
Leikkaavuudet (E):

030004P Introduction to Information Retrieval 0.0 cp

ECTS Credits:
1 ECTS credits / 27 hours of work

Language of instruction:
Finnish

Timing:
Architecture 3. spring semester, period I; Biochemistry 3. autumn semester; Biology 3. autumn semester, period I; Chemistry 3. autumn semester, period II; Computer Science and Engineering 2. spring semester, period IV; Electronics and Communications Engineering 3. spring semester; Geosciences 2. spring semester, period IV; Geography 1. and 3. spring semester, period III; Industrial Engineering and Management 3. year (Master's degree students in Industrial Engineering and Management 1st year.); Information Processing Sciences 1. year; Mathematics and Physics 1. spring semester, period II; Mechanical Engineering 3. year; Mining Engineering and Mineral Processing 3. year; Process and Environmental Engineering 2. year, period II.

Learning outcomes:
Upon completion of the course, the students:
- can search scientific information,
- can use the most important databases of their discipline,
- know how to evaluate search results and information sources,
- can use the reference management tool

Contents:
Scientific information retrieval process, the most important databases and publication channels of the discipline, evaluation of the reliability of information sources and RefWorks reference management tool.

Mode of delivery:
Blended teaching: classroom training, web-based learning material and exercises, a group assignment.

Learning activities and teaching methods:
Training sessions 8 h, group working 7 h, self-study 12 h

Target group:
Compulsory for all bachelor degree students of Faculty of Information Technology and Electrical Engineering, Faculty of Technology and Faculty of Science. Compulsory also for those Master's degree students in Industrial Engineering and Management who have no earlier studies in the information skills. Optional for the students of biochemistry.

Prerequisites and co-requisites:
-
Recommended optional programme components:

Recommended or required reading:
Web learning material Tieteellisen tiedonhankinnan opas http://libguides.oulu.fi/tieteenlentiedonhankinta (in Finnish)

Assessment methods and criteria:
Passing the course requires participation in the training sessions and successful completion of the course assignments.

Grading:
pass/fail

Person responsible:
Ursula Heinikoski

Working life cooperation:
-

Other information:
-

523990A: Bachelor's Thesis / Electronics and Communications Engineering, 8 cp

Validity: 01.08.2007 -
Form of study: Intermediate Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Opintokohteen kielet (E): Finnish

ECTS Credits:
8
Language of instruction:
Finnish, can be written in English if needed.

Timing:
Periods 1-6

Learning outcomes:
The student is able to set objectives for a given assignment. He/she is able to analyze the theme coherently, with emphasis on the key issues. The student is able to use sources of information critically. The student is able to present the planned and implemented solution clearly and to justify the choices he/she took, and to assess the functionality of the solution using relevant testing and evaluation methods. In addition, he/she is able to compare the results against the set objectives. The student is able to produce impeccable, clear and finalized text, in line with technical and scientific writing practices.

Contents:
The student chooses the theme for the thesis in cooperation with his/her supervisor.

Mode of delivery:
The thesis is written towards the end of the BSc studies, typically during the third year.

Learning activities and teaching methods:
Independent work.

Target group:
Students of Electrical Engineering.

Prerequisites and co-requisites:
Basic studies.

Recommended optional programme components:
BSc preparatory module, Technical communication.

Recommended or required reading:
Assessment methods and criteria:
BSc thesis and related maturity essay.

Grading:
Grading: pass/fail.

Person responsible:
Professors and researchers in the Departments of Electrical Engineering and Communications Engineering.

Working life cooperation:
Yes.

Other information:

521010A: Maturity Test for Bachelor's Degree, Electronics and Communications Engineering, 0 cp

Form of study: Intermediate Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Opintokohteen kielet (E): Finnish

ECTS Credits:
0; The maturity test is integrated in the BSc Thesis credits (8 ECTS).

Language of instruction:
Finnish/Swedish/other

Timing:
Periods 1-4

Learning outcomes:
After the maturity test, the student has demonstrated that his/her language skills meet the requirements of the work life.

Contents:
The aim of the maturity test is to confirm the student's familiarity of the thesis area as well as his/her command of the domestic language of his/her school education.

Mode of delivery:
The maturity test is written in a controlled event, on a topic provided by the thesis supervisor.

Learning activities and teaching methods:
Written essay, approximately 3 pages.

Target group:

Prerequisites and co-requisites:
The maturity test can be written after all other components of the BSc thesis are completed.

Recommended optional programme components:

Recommended or required reading:
BSc Thesis.

Assessment methods and criteria:
The maturity test is evaluated and approved by the thesis supervisor.
Read more about assessment criteria at the University of Oulu webpage.

Grading:
Pass/fail.

Person responsible:
Thesis supervisor.

Working life cooperation:

Other information:
521036A: Seminar for Bachelor`s Degree, Electronics and Communications Engineering, 0 cp

Form of study: Intermediate Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Jari Hannu
Opintokohteen kielet (E): Finnish
Voidaan suorittaa useasti (E): Yes

No course descriptions.

900060A: Technical Communication, 2 cp

Validity: 01.08.2005 -
Form of study: Intermediate Studies
Type: Course
Unit: Languages and Communication
Grading: 1 - 5, pass, fail
Opintokohteen kielet (E): Finnish
Leikkaavuudet (E):
  ay900060A  Technical Communication (OPEN UNI)  2.0 cp
  470218P  Written and Oral Communication  3.0 cp

Proficiency level:
-
Status:
This course unit is compulsory for students of Electrical Engineering, Computer Science, Communications Technologies and Engineering Mechanical Engineering, Process and Environmental Engineering.
Required proficiency level:
-
ECTS Credits: 2 credits
Language of instruction: Finnish
Timing:
1st year: Process and Environmental Engineering
2nd year: Communications Technologies
3rd year: Geoscience; Mechanical Engineering; Electrical Engineering, Computer Science and Engineering Technologies

Mode of delivery: Multimodal teaching
Learning activities and teaching methods:
Contact hours ca. 20 h and independent group work or self-study ca. 34 h.
Target group:
Prerequisites and co-requisites:
-
Recommended optional programme components:
-
Recommended or required reading:
Kauppinen, Anneli & Nummi, Jyrki & Savola, Tea: Tekniikan viestintä: kirjoittamisen ja puhumisen käsikirja (EDITA); Nykänen, Olli: Toimivaa tekstiä: Opas tekniikasta kirjoittaville (TEK) and material in Optima study environment.

Assessment methods and criteria:
Active participation in contact teaching, independent study and completion of given assignments. Read more about assessment criteria at the University of Oulu webpage.

Grading:
Pass / fail

Person responsible:
Kaija Oikarainen

Working life cooperation:

Other information:
All students are required to attend the first meeting of the course unit so the work groups can be formed and work started in a timely and efficient manner. When signing up for the course unit, you should keep in mind that completing it requires a responsible attitude and a strong commitment to the work because the teamwork-based exercises rely heavily on the participation and activity of the students.

If the student is involved in the University's student associations or functions in a position of trust in university government, student union administration or Oulun Teekkariyhdistys ry (or in its subordinate guilds), he/she may be relieved of some of the group communication exercises. These compensatory actions must always be agreed upon separately with the course unit's teacher. The student must present an official statement from a person in charge of the governing body or association, which details the student's tasks and involvement with that body or association. Participation that took place over five years ago does not entitle the student to any compensation.

H451229: Module of the Option, Electronics Design, 60 - 87 cp

Validity: 01.08.2011 -
Form of study: Other Entity
Type: Study module
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Opintokohteen kielet (E): Finnish

No course descriptions.

Compulsory

A451221: Module of the Option, Electronics Design, 30 - 38 cp

Validity: 01.08.2005 -
Form of study: Module of the Option
Type: Study module
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Opintokohteen kielet (E): Finnish

No course descriptions.

Compulsory studies, Total 33 ECTS cr

521401S: Electronics Design II, 6 cp

Validity: 01.08.2017 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Ilkka Nissinen, Jan Nissinen
Opintokohteen kielet (E): English

ECTS Credits:
6 ECTS

Language of instruction:
In Finnish (In English if needed).

Timing:
Autumn, period 1

Learning outcomes:
Student
1. should be able to explain the structures and operating principles of the passive and active (BJT and MOS) components available for use in modern IC technologies
2. should be able to analyze and design integrated electronic blocks based on these components, such as operational amplifiers, comparators and sampling circuits
3. should be able to estimate and minimize the effects of noise in electrical circuits
4. should be able to explain the terminology used with DA and AD conversion and converters
5. should be able to analyze and outline the main architectural principles and also to evaluate the characteristics of DA and AD converters

Contents:
Modeling of BJT and MOS transistors, CMOS and BJT building blocks especially as IC-realizations, noise and analysis of noise, internal structure of operational amplifiers, critical parameters, comparators, S/H-circuits, structures and properties of A/D and D/A converters.

Mode of delivery:
Face-to-face teaching

Learning activities and teaching methods:
Face-to-face teaching: Lectures 30h, exercises 20h. Self study: a small design work 30h. Learning without guidance either privately or in a group 80h.

Target group:
Students of Electrical engineering. Other students of the University of Oulu may also participate.

Prerequisites and co-requisites:
Principles of electronics design, Electronics design I

Recommended optional programme components:
-

Recommended or required reading:

Assessment methods and criteria:
The course unit is passed by a final exam or by a two midterm exams and a passed design work. Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course unit utilizes a numerical grading scale 1-5.

Person responsible:
Ilkka Nissinen
Working life cooperation:
No
Other information:
-

521405A: Electronic System Design, 5 cp

Form of study: Intermediate Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Kari Määttä
Opintokohteen kielet (E): Finnish

ECTS Credits:
5

Language of instruction:
English/Finnish.

Timing:
Period 1

Learning outcomes:
1. is able to choose the optimum method of the choices presented in the course in the field of power supply, thermal design, grounding, and routing of the high speed signals.
2. is able to calculate problems, caused by electrical disturbances, crosstalk and non-idealities of electrical components.
3. can calculate reliability of an electrical device or system.
4. The main goal of the course is to introduce methods and techniques needed in designing larger electronic entities such as equipment and systems.

Contents:
Power supplies, thermal design, grounding, transmission of fast signals by using transmission lines, electrical disturbances, crosstalk, non-idealities of electrical components.

Mode of delivery:
Face-to-face teaching.

Learning activities and teaching methods:
The course includes 30 h of lectures and 20 h of exercises.

Target group:
Primarily in electrical engineering students. Other University of Oulu students can complete the course.

Prerequisites and co-requisites:
Both Principles of Electronics Design and Analogue Electronics I must have been accepted.

Recommended optional programme components:
The course is an independent entity and does not require other studies carried out at the same time.

Recommended or required reading:
Assessment methods and criteria:
The course is passed by means of a final exam. Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course unit utilizes a numerical grading scale 0 - 5. In the numerical scale 0 stands for a fail.

Person responsible:
Kari Määttä

Working life cooperation:
No.

Other information:

521326S: Radio Engineering 1, 5 cp

Validity: 01.08.2015 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Aarno Pärssinen, Risto Vuohtoniemi

Opintokohteen kielet (E): Finnish
Leikkaavuudet (E):

521326S-01 Radio Engineering 0.0 cp
521326S-02 Exercise work, Radio engineering 1 0.0 cp
521335S-01 Radio engineering, partial credit 0.0 cp
521335S-02 Radio engineering, partial credit 0.0 cp
521335S Radio Engineering 6.0 cp

ECTS Credits:
5

Language of instruction:
English

Timing:
Fall, period 2

Learning outcomes:
1. learns key components of radio transceivers used in wireless communications including LTE and 5G.
2. knows different kind of impedance matching methods and can design the impedance matching network using lumped components and microstrip lines.
A student can also explain factors, which are limiting the bandwidth of impedance matching networks. Smith chart (admittance/impedance chart).
3. will be able to design a low noise RF amplifier. The amplifier is designed that the noise figure is minimized or the gain is maximized. The impedance matching can also be made for the constant gain.
4. knows single sideband and double sideband noise in mixers. A student will be able to design balanced and double balanced mixer and knows the advantages and the disadvantages of these mixers.
5. will be able to design passive microwave components like a Wilkinson power divider, a directional coupler and hybrids.
6. can explain basic principles of RF-oscillators. A student can design a cross-coupled oscillator and voltage controlled oscillator.
7. knows concept of noise, non-linearity and dynamic range as used in radio frequency communications.
8. can classify power amplifiers and will be able in the basic case design the matching network for a power amplifier.

**Contents:**
Noise, non-linearity, impedance matching using lumped components, microstrip matching networks, low noise amplifier (LNA) design, active and passive mixers design, Wilkinson power dividers, directional couplers, hybrids, automatic gain control (AGC), cross-coupled oscillator, voltage controlled oscillators, power amplifier design.

**Mode of delivery:**
Face-to-face teaching

**Learning activities and teaching methods:**
Lectures 24 h, exercises 16 h and the compulsory RF design work with ADS simulation software (20 h).

**Target group:**
1st year M.Sc. and WCE-RF students. 2nd year M.Sc. (Telecom.) and WCE-RAN students.

**Prerequisites and co-requisites:**
Basics of Radio Engineering

**Recommended optional programme components:**

- 

**Recommended or required reading:**

**Assessment methods and criteria:**
The course is passed with a final examination and the accepted simulation work report. In the final grade of the course, the weight for the examination is 0.75 and that for the simulation work 0.25. Read more about assessment criteria at the University of Oulu webpage.

**Grading:**
The course unit utilizes a numerical grading scale 1-5.

**Person responsible:**
Risto Vuohtoniemi, Aarno Pärssinen.

**Working life cooperation:**
No

**Other information:**

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521088S: Optoelectronics, 5 cp

**Validity:** 01.01.2014 -
**Form of study:** Advanced Studies
**Type:** Course
**Unit:** Electrical Engineering DP
**Grading:** 1 - 5, pass, fail
**Teachers:** Juha Kostamovaara
**Opintokohteen kielet (E):** Finnish
ECTS Credits: 5
Language of instruction: Finnish
Timing: Autumn, period 1

Learning outcomes:
1. is able to explain the principles of operation of optical fibres and waveguides
2. is able to explain the principles of operation of semiconductor light sources and photo detectors, and knows the factors affecting their performance
3. is able to outline the circuit-level structures for optical transmitter circuits and photo detector preamplifiers
4. is able to compare their performance in terms of the main performance parameters

Contents:

Mode of delivery:
Face-to-face teaching

Learning activities and teaching methods:
Lectures 30 h and exercises 20 h, may include a seminar.

Target group:
This course is targeted mainly for the students of electrical engineering degree program, but available for other students as well.

Prerequisites and co-requisites:
Principles of semiconductor devices.

Recommended optional programme components:
This course is independent, no other components are recommended simultaneously.

Recommended or required reading:

Assessment methods and criteria:
Final exam.
Read more about assessment criteria at the University of Oulu webpage.

Grading:
Numerical grading scale 1-5.

Person responsible:
Juha Kostamovaara

Working life cooperation:
Does not apply.

Other information: 

521423S: Embedded System Project, 5 cp
Form of study: Advanced Studies  
Type: Course  
Unit: Computer Science and Engineering DP  
Grading: 1 - 5, pass, fail  
Teachers: Juha Röning  
Opintokohteen kielet (E): English  

ECTS Credits:  
5  
Language of instruction:  
Lecturing in Finnish, material available in English  
Timing:  
Spring, periods 3-4.  

Learning outcomes:  
1. After passing the course, the student is familiar with the design process of an embedded system, from specifying the application leading to the requirement specification for the device, and then to having produced a functional prototype of the defined system.  
2. The student is more familiar with the roles of the client and the system developer during the requirement specification, and the role of the iterations as a part of the whole design process. From the specifications, the student is familiar with the process of choosing the suitable hardware components, circuit design and implementation. In the end, the student is also able to know the factors arising from the SW/HW partitioning process of the actual implementation, and the concept of SW/HW dualism. The student can then better utilize the basic development tools used for embedded system design and recognize their possible advantages and disadvantages.  
3. The student is more familiar with the testing and problem solving methodology related to the prototype implementation of an embedded system, to have the prototype working correctly according to the specifications.  

Contents:  
The embedded system design process, from initial specification to implementation of a first functional prototype and demonstrating its functionality in practice. The application can be suggested by the student group, or chosen from the topics suggested by the course organizers. During the work, the students familiarize themselves with modern design tools and methodologies related to embedded system design (according to the microcontroller the student group has chosen to utilize in their work). Most commonly used platforms on the course include STM, Atmel and Microchip based platforms.  

Mode of delivery:  
Lectures, face-to-face tutoring and self-study.  

Learning activities and teaching methods:  
The course is run as a project work in groups of three with progress follow-up reporting meetings. Lectures 10 h, laboratory exercise in period 3-4 120 h.  

Target group:  
Computer Science and Engineering students and other Students of the University of Oulu.  

Prerequisites and co-requisites:  
811122P Introduction to Programming  
521412A Digital Techniques I  
Also recommended; 521275A Embedded Software Project, 521432A Electronics Design I.  

Recommended optional programme components:  
The course is an independent entity and does not require additional studies carried out at the same time.  

Recommended or required reading:
Assessment methods and criteria:
Project work. Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course unit utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible:
Juha Röning

Working life cooperation:
None.

521406S: Digital Techniques 3, 7 cp

Validity: 01.08.2017 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Jukka Lahti
Opintokohteen kielet (E): Finnish

ECTS Credits:
7 ECTS

Language of instruction:
In Finnish. Exams can be arranged in English on demand.

Timing:
Spring, peridos 3-4

Learning outcomes:
Student
1. knows the phases of the design process of hardware parts of digital system implemented in FPGA or ASIC technologies, and understands their purpose, and the problems and aims associated with different design tasks
2. is able to use the tools needed in industrial design projects.

Contents:

Mode of delivery:
Classroom

Learning activities and teaching methods:
 Lectures 20h/ exercises 20h (group work)/ independent work 120h.

Target group:
Primarily electrical and computer science and engineering students. Also other student of University of Oulu can take the course.

Prerequisites and co-requisites:
Digital techniques 1 and Digital techniques 2
Recommended optional programme components:
-
**Recommended or required reading:**
Lecture textbook (in finnish) and literature announced during course.

**Assessment methods and criteria:**
Final exam and a design excercise, or weekly assignments consisting of theoretical and design exercises.
Read more about [assessment criteria](http://example.com) at the University of Oulu webpage.

**Grading:**
1-5, The grade is the average of the exam and the design exercise, or the grade of the weekly assignments.

**Person responsible:**
Jukka Lahti

**Working life cooperation:**
No

**Other information:**
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**A451289: Advanced module/Electronics design, electronics design (obligatory), 15 - 40 cp**

- **Validity:** 01.08.2011 -
- **Form of study:** Advanced Module
- **Type:** Study module
- **Unit:** Electrical Engineering DP
- **Grading:** 1 - 5, pass, fail
- **Opintokohteen kielet (E):** Finnish

No course descriptions.

*Choose at least 15 ECTS cr*

**521348S: Statistical Signal Processing 1, 5 cp**

- **Validity:** 01.08.2016 -
- **Form of study:** Advanced Studies
- **Type:** Course
- **Unit:** Electrical Engineering DP
- **Grading:** 1 - 5, pass, fail
- **Teachers:** Janne Lehtomäki, Juntti, Markku Johannes
- **Opintokohteen kielet (E):** Finnish
- **Leikkaavuudet (E):**
  - 521484A Statistical Signal Processing 5.0 cp

**ECTS Credits:**
5 ECTS

**Language of instruction:**
English
Timing:
The course is held in the autumn semester, during period 1. It is recommended to complete the course at the 1st semester of the master studies.

Learning outcomes:
Upon completion the student
1. knows the key tools of linear algebra and optimization and can apply them in solving signal processing problems.
2. understands the key concepts in estimation theory such as the classical and Bayesian framework.
3. masters the most important estimation principles such as minimum variance, maximum likelihood, least squares and minimum mean square error estimators.
4. can derive an estimator for a given criterion and basic data models.
5. can use the methodology of estimation theory to analyze the performance of estimators.
6. understands the basics of detection and classification theory: hypothesis testing, receiver operating characteristics (ROC), matched filtering, estimator-correlator.

Contents:
Review of probability, linear algebra, random variables and stochastic processes; SVD (Singular value decomposition), QR decomposition, estimation theory, minimum variance unbiased estimator, Cramer-Rao lower bound, linear models, general minimum variance unbiased estimation, best linear unbiased estimators, maximum likelihood estimation, least squares estimation, Bayesian estimation, linear Bayesian estimation, Wiener filters, statistical decision theory, receiver operating characteristics, hypothesis testing, matched filter, estimator-correlator.

Mode of delivery:
Face-to-face teaching and e-learning tool usage

Learning activities and teaching methods:
Face-to-face teaching (lectures and exercises) 50h, Matlab simulation exercises in groups 30 h, independent work & passed assignment 50 h.

Target group:
Electrical, communications and computer science and engineering students.

Prerequisites and co-requisites:
The required prerequisite is the completion of the following courses prior to enrolling for the course: 031080A Signal Analysis, 031021P Probability and Mathematical Statistics, 031078P Matrix Algebra, 521330A Telecommunication Engineering.

Recommended optional programme components:
521323S Wireless communications I and 031051S Numerical Matrix Analysis are recommended to be taken in parallel.

Recommended or required reading:
Parts from books:
5. Other literature, lecture notes and material.

Assessment methods and criteria:
Completing the simulation project tasks, and a mid-term exam during the course. The mid-term exams can be retaken by a final exam later. In the final grade of the course, the weight for the examination is 0.7 and that of project report 0.3.
Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course utilizes a numerical grading scale 1-5. In the numerical scale zero (0) stands for a fail.

**Person responsible:**
Janne Lehtomäki and Markku Juntti

**Working life cooperation:**
No

**Other information:**
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**521435S: Electronics Design III, 6 cp**

**Form of study:** Advanced Studies

**Type:** Course

**Unit:** Electrical Engineering DP

**Grading:** 1 - 5, pass, fail

**Teachers:** Ilkka Nissinen

**Opintokohteen kielet (E):** Finnish

**ECTS Credits:**
6

**Language of instruction:**
In Finnish (English as a book examination)

**Timing:**
Autumn, period 2

**Learning outcomes:**
1. On completion of the study module students should be able to detail the advantages of differential signal processing in IC realizations and
2. to analyze and design differential amplifiers and other electronic blocks for implementation in an IC environment.
3. They should be able to explain how an SC (switched capacitor) technology functions and to apply such a technology to sampling and filtering.
4. They should also be able to describe the principles for realizing continuous filters in IC technologies, to explain the principles of the delta–sigma technology
5. and to apply it for realizing integrated DA and AD converters.
6. They should be able to account for the functioning, use and architecture of a phase-locked loop,
7. to explain the functioning of an MOS transistor in the area of weak inversion and to indicate how use can be made of this functional area in circuit design.

**Contents:**
Advanced operational amplifier topologies, especially differential ones, bandgap and PTAT bias circuits and references, problems related to the design of multi-stage amplifiers (output stages, LP/LV implementations), signal sampling and error sources related to it, SC-techniques (especially in filters), implementation principles of continuous time IC filters, DS techniques in general and particularly in AD/DA converters, operations with frequency/phase domain signals, design of IC layout.

**Mode of delivery:**
Face-to-face teaching

**Learning activities and teaching methods:**
Lectures 30h and Exercises 20 h and 4h layout demo. Self-study or in a group of two persons: laboratory exercise 36 h (CAD tools used in IC design and familiarization into the complete analogue IC design flow) and learning without guidance either privately or in a group 69 h.

**Target group:**
Electrical Engineering students and other Students of the University of Oulu.
Electrical Engineering students and other Students of the University of Oulu.

Prerequisites and co-requisites:
Electronics Design II, Filters, Introduction to Microfabrication Techniques (recommended).

Recommended optional programme components:
The course is an independent entity and does not require additional studies carried out at the same time

Recommended or required reading:
Lecture notes
or D. A. Johns K. Martin: Analog integrated circuit design, Wiley Sons 1997 1st edition chapter 6, chapter 8 partially, 9, 10, 14, 15

Assessment methods and criteria:
Passed final exam or 2 midterm exams and exercise work.
Read more about assessment criteria at the University of Oulu webpage.

Grading:
Numerical grading scale 1-5.

Person responsible:
Ilkka Nissinen

Working life cooperation:
No

Other information:
-

521453A: Operating Systems, 5 cp

Form of study: Intermediate Studies
Type: Course
Unit: Computer Science and Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Juha Röning
Opintokohteen kielet (E): English
Leikkaavuudet (E):
   ay521453A   Operating Systems (OPEN UNI)   5.0 cp

ECTS Credits:
5

Language of instruction:
In Finnish, material available in English

Timing:
Spring, period 4

Learning outcomes:
1. is capable of explaining the basic structure and functioning of operating system
2. is able to point the problems related to process management and synchronization as well as is able to apply learned methods to solve basic problems
3. is capable of explaining the cause and effect related to deadlocks and is able to analyse them related to common circumstances in operating systems

4. is able to explain the basics of memory management, the use of virtual memory in modern operating systems as well as the structure of the most common file-systems.

Contents:
Operating system structure and services, process management, process synchronization, deadlocks, memory management, virtual memory, file-systems

Mode of delivery:
Face-to-face.

Learning activities and teaching methods:
Lectures 36 h, laboratory exercise 4 h, the rest as independent work. The laboratory work, including pre-exercise and guided exercise performed in a group of one or two students in the unix environment, covers core topics of the course.

Target group:
Computer Science and Engineering students and other Students of the University of Oulu.

Prerequisites and co-requisites:
521141P Elementary Programming, 521286A Computer Systems or 521142A Embedded Systems Programming and 521267A Computer Engineering

Recommended optional programme components:
The course is an independent entity and does not require additional studies carried out at the same time.

Recommended or required reading:

Assessment methods and criteria:
The course is passed the final examination and accepted laboratory working.
Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course unit utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible:
Juha Röning and Jaakko Suutala (lectures)
Anna-Mari Wartiainen (exercises)

Working life cooperation:
-

Other information:
-

521457A: Software Engineering, 5 cp

Form of study: Intermediate Studies
Type: Course
Unit: Computer Science and Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Juha Röning
Opintokohteen kielet (E): English
Leikkaavuudet (E):
ay521457A Software Engineering (OPEN UNI) 5.0 cp
ECTS Credits:
5

Language of instruction:
Finnish. Material available in English.

Timing:
Spring, period 3.

Learning outcomes:
1. After finishing the course, the student knows the basic concepts of software engineering
2. The student also knows the different areas of project management, the phases of software development
3. The student can defines goals and tasks for each phase of development
4. The student knows the principles of secure software development
5. The student knows the metrics used in software engineering and is able to apply them
6. The student is familiar with tools commonly used in software engineering.

Contents:
Problematics of software development and the special features of real-time systems in this regard. Software development is viewed in regard to project management and actual implementation: 1. process models, 2. requirements specification, 3. project management basics: design, metrics, risk management, resource management, follow up, quality control, product control, 4. software testing methods and strategies, 5. introduction to object-oriented analysis and design. 6. Agile software development. 7. Secure software engineering

Mode of delivery:
Face-to-face or online course

Learning activities and teaching methods:
The course consists of lectures and independent practical exercises. The course is completed by a final exam or learning diaries and successfully completed practical exercises. Lectures 30 h, laboratory design (in period 3) 8 h, the rest of the self-study.

Target group:
Computer Science and Engineering students and other Students of the University of Oulu.

Prerequisites and co-requisites:

Recommended optional programme components:
The course is an independent entity and does not require additional studies carried out at the same time.

Recommended or required reading:

Assessment methods and criteria:
Final exam and accepted laboratory exercise.
Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course unit utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible:
Juha Röning

Working life cooperation:

521025S: Power Electronics, 5 cp
Validity: 01.08.2005 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Kari Määttä
Opintokohteen kielet (E): Finnish

ECTS Credits: 5
Language of instruction: Finnish.
Timing: Period 3
Learning outcomes:
1. is able to discuss and write on the subject by using the terminology in the field of switching power supplies.
2. can analyze the operation of different switching power supplies in continuous and discontinuous conduction mode and in steady state operation.
3. is able to design various switching power supplies different dc-dc-applications.
4. can calculate loss mechanisms in design and estimate their effect on the efficiency of the switching converter. He or she is able to explain the basics of the ac-modeling of switching.
5. The course provides the basic knowledge on switched-mode power supplies so that the student recognizes the typical terminology and different topologies.

Contents:
Introduction to switched-mode converters, Steady-state analysis in continuous and discontinuous conduction modes, Transformer isolated converters. Power factor.

Mode of delivery:
Face-to-face teaching.
Learning activities and teaching methods:
The course includes 30 h lectures and 20 h of exercises.

Target group:
Primarily in electrical engineering students. Other University of Oulu students can complete the course

Prerequisites and co-requisites:
Courses Circuit Theory I-II, Electronics Design I-II or equivalent.

Recommended optional programme components:
The course is an independent entity and does not require other studies carried out at the same time.

Recommended or required reading:
Lecture notes.

Assessment methods and criteria:
The course is passed by means of a final exam.
Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course unit utilizes a numerical grading scale 0 - 5. In the numerical scale 0 stands for a fail.

Person responsible:
Kari Määttä

Working life cooperation:
No

Other information:

521225S: RF Components and Measurements, 5 cp

Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Teirikangas, Merja Elina
Opintokohteen kielet (E): Finnish

ECTS Credits:
5 ECTS credits / 132,5 hours of work

Language of instruction:
Finnish. English, if there are at least 3 international students in class.

Timing:
The course is held in the 4th period. It is recommended to complete the course during Master level studies.

Learning outcomes:
1. After completing the course the student has knowledge of the behavior of passive components at RF frequencies, knows the fabrication methods of components and is also able to apply the knowledge to practical applications.

2. The student also knows the operating principles of transfer lines, antennas and filters and of their design.

3. The student can apply the fundamentals of RF and microwave techniques to measurements, is able to make the measurements of RF components, has knowledge of the operating principles of RF region measurement equipment and is able to compare the usability of different.

4. The student knows how to perform typical measurements of RF region magnitudes (power, frequency, impedance and noise).

Contents:
Fundamentals of RF and microwave techniques, components in microwave circuits, measurement instruments, measuring of power, frequency, impedance and noise, time-domain and active circuit measurements.

Mode of delivery:
Face-to-face teaching, independent design exercises and laboratory exercises.

Learning activities and teaching methods:
Lectures 24 h, design exercises 20 h, laboratory exercises 20 h, independent work 68,5 h.

Target group:
Masters students on electrical engineering

Prerequisites and co-requisites:
The recommended prerequisite is the completion of the following courses prior to enrolling for the course unit: Electronic Components and Materials, Electronic Measurement Techniques, Basics of Radio Engineering.

Recommended optional programme components:
The course is an independent entity and does not require additional studies carried out at the same time.

Recommended or required reading:

Assessment methods and criteria:
Final exam, design exercises and laboratory exercises. Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible:
Merja Teirikangas

Working life cooperation:
No.

Other information:

521300S: Electronics Design and Construction Exercise, 6 cp

Validity: 01.08.2015
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Kari Määttä
Opintokohteen kielet (E): Finnish
Leikkaavuudet (E):
  521441S Electronics Design and Construction Exercise 6.5 cp

ECTS Credits:
6
Language of instruction:
Finnish, English
Timing:
Periods 1-4

Learning outcomes:
1 is able to carry out all the stages needed to develop an electronic circuit or device starting from independent creation and design work to realization, testing and technical documentation.
2 is able to use independently without any help professional methods, software packages, measurement devices and tools.
Objective: To familiarize the student with independent electrical circuit and system design and with the methods and tools used in the design process. The course prepares the student for the diploma work in the area of circuits and system design.

Contents:
Design and construction of an electronic device or a part of a device according to the given specification. The task can be part of an industrial research or a product design project or part of the research project going on in Electronics or other laboratory. The subject of the work can be own suggestion of the student or a pre-selected course subject, which enables comprehensive training of skills needed for the design of a modern electronic device.

Mode of delivery:
Independent work.

Learning activities and teaching methods:
Independent design and construction work 180h

Target group:
Primarily in electrical engineering students. Other University of Oulu students can complete the course

Prerequisites and co-requisites:
Student must have passed following courses: Analogue Electronics I-II, Digital Techniques I-II, Electronic System Design and Filter Theory.

Recommended optional programme components:
The course is an independent entity and does not require other studies carried out at the same time.

Recommended or required reading:
Not defined

Assessment methods and criteria:
The task can be carried out by a student or by a team of two students. The grade will be decided on the basis of the statement of the instructor, realization of the device and the report provided by the student.

Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course unit utilizes a numerical grading scale 0 - 5. In the numerical scale 0 stands for a fail.

Person responsible:
Kari Määttä

Working life cooperation:
No

521402S: Telecommunications Circuit Design, 6 cp

Validity: 01.08.2017 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Rahkonen, Timo Erkki
Opintokohteen kielet (E): Finnish

ECTS Credits:
6 ects / 42 contact hours + design excercise
Language of instruction: English/Finnish

Timing:
Autumn, 1st period of the last year of studies

Learning outcomes:
After completing the course the student
- knows the most usual schematic structures and dimensioning principles of typical telecommunication circuit blocks
- can sketch the spectral effects of non-linear and time-varying circuit blocks
- can evaluate the performance of the available IC process node

Contents:
The course gives the background needed in the design of RFICs and other analog telecommunication circuit blocks.

Mode of delivery:
Face-to-face teaching

Learning activities and teaching methods:
28 hours of lectures, 14 of exercises, and a relatively large design task.

Target group:
Last year MSc students with strong analog design background

Prerequisites and co-requisites:
Strong background in analog transistor level design is required.

Recommended optional programme components:
Needs electronics design 2-3 background

Recommended or required reading:
Handouts

Assessment methods and criteria:
Graded based on the final exam. The design exercise needs to be passed.

Grading:
Numerical scale 0-5. 0 is fail, 5 the best.

Person responsible:
Prof. Timo Rahkonen

Working life cooperation:
The topics are strongly related to the skills needed in the industry

Other information:
The course is the last advanced course in analog design, and requires the basic knowledge of transistor level analog design and IC design.

521448S: Physical Design of Digital Integrated Circuits, 5 cp

Validity: 01.08.2018 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Jukka Lahti
Opintokohteen kielet (E): Finnish
**ECTS Credits:**
5 ECTS credits / 135 hours of work

**Language of instruction:**
English

**Timing:**
The course is held on spring semesters, but can in addition be held on autumn semesters on demand.

**Learning outcomes:**
Upon completion of the course the student
- understands the technologies and the physical design and verification flow of digital integrated circuit
- knows how a digital integrated circuit is implemented using logic synthesis and layout design electronic design automation tools.

**Contents:**
1. Technologies and libraries
2. Design and verification flow overview
3. Layout-driven, power-optimized logic synthesis process
4. Standard cell layout design, including power-network and clock-tree synthesis
5. Post-layout verification

**Mode of delivery:**
Blended teaching that consists of lectures, laboratory exercises in computer classes and independent design exercises. Mode of delivery varies between course implementations based on the design tools used.

**Learning activities and teaching methods:**
1. Lectures 16 hours.
2. Design tool exercises in computer class or own computer 32 h
3. Independent work (design exercise, course report) 87 h

**Target group:**
Master and doctoral students in electrical and computer engineering

**Prerequisites and co-requisites:**
521301A Digital techniques 1, 521404A Digital techniques 2 or equivalent skills

**Recommended optional programme components:**
The course 521406S Digital techniques 3 that covers the logical design of digital integrated circuits is recommended for students specializing in digital circuits and systems design.

**Recommended or required reading:**
Recommended reading:
Khosrow Golshan: Physical design essentials: an ASIC design implementation perspective (Springer, 2007)
Other reading material will be delivered during the course.

**Assessment methods and criteria:**
Students must complete the laboratory exercises and write a report that describes the digital integrated circuit design flow as it was implemented in the laboratory exercises. Grading is based on the report. Read more about assessment criteria at the University of Oulu web page.

**Grading:**
The course utilizes a numerical grading scale 1 – 5. In the numerical scale zero stands for a fail.

**Person responsible:**
Jukka Lahti

**Working life cooperation:**
The course may include guest lecturers from electronics design automation software companies.
**Other information:**

Choose optional Studies (39 ECTS cr or until the degree is 120 ECTS cr): Electronics

521410S: Special Course in Electronic Design, 4 - 7 cp

**Validity:** 01.08.2006 -
**Form of study:** Advanced Studies
**Type:** Course
**Unit:** Electrical Engineering DP
**Grading:** 1 - 5, pass, fail
**Teachers:** Rahkonen, Timo Erkki
**Opintokohteen kielet (E):** Finnish

**ECTS Credits:**
4-7 ECTS cr, depending on the yearly contents.

**Language of instruction:**
Finnish or English (if there are at least two foreign students).

**Timing:**
Varies, intensive implementation periods 1-4

**Learning outcomes:**
Vary depending on the content.

**Contents:**
The contents will be fixed yearly during the spring semester. It may be related to RFIC design, or non-linear circuit analysis, for example.

**Mode of delivery:**
Classroom

**Learning activities and teaching methods:**
Varies yearly. The course may contain exercises or a design exercise.

**Target group:**
Electrical Engineering MSc students

**Prerequisites and co-requisites:**
Background in circuit theory and analog and RF design.

**Recommended optional programme components:**
-

**Recommended or required reading:**
Depends on the contents.

**Assessment methods and criteria:**
Depends on the implementation. May contain design exercise.
Read more about assessment criteria at the University of Oulu webpage.

**Grading:**
1-5

**Person responsible:**
Prof. Timo Rahkonen
Working life cooperation:
-
Other information:
-

521327S: Radio Engineering II, 6 cp

Validity: 01.08.2015 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Risto Vuohtoniemi, Aarno Pärssinen
Opintokohteen kielet (E): English
Leikkaavuudet (E):
  521375S  Design of Transceivers  5.0 cp
  521375S-01 Design of tranceivers, partial credit  0.0 cp
  521375S-02 Exercise work, Radio Engineering II  0.0 cp

ECTS Credits:
6 ECTS cr
Language of instruction:
English
Timing:
Spring, period 3
Learning outcomes:
1. understands radio system and RF design for modern wireless equipment like cellular phones.
2. recognizes the blocks of a transceiver and can explain the operating principle of a transceiver.
3. can classify different architectures used in a single and a multi-antenna transceiver and understand the basis for them.
4. will be able to define parameters used in the transceiver system level design and can design a transceiver at the system level so that the requirements for the system are fulfilled.
5. knows nonlinear distortion and can design the automatic gain control in the system level.
6. will be able to explain factors, which are important for the selection of D/A- and A/D-converters and can derive various methods to create the in phase and the quadrature components of a received signal.
7. understands the principles of frequency synthesis in a transceiver.
8. understands principles of key implementation technologies of radio transceivers and relation to electronics.
Contents:
Designing a transceiver at the system level, transceiver architectures, performance characteristics of transceivers, nonlinearities, factors which limit the performance of a transceiver, placement of the A/D-converter in a receiver, frequency synthesis, design and implementation examples.
Mode of delivery:
Face-to-face teaching
Learning activities and teaching methods:
Lectures 32 h and the compulsory design exercise with ADS simulation software (54 h).

**Target group:**
1st year M.Sc. and WCE-RF students

**Prerequisites and co-requisites:**
Radio Engineering I

**Recommended optional programme components:**
- 

**Recommended or required reading:**

**Assessment methods and criteria:**
The course is passed with a final examination and the accepted simulation work report. In the final grade of the course, the weight for the examination is 0.75 and that for the simulation work 0.25. Read more about assessment criteria at the University of Oulu webpage.

**Grading:**
The course unit utilizes a numerical grading scale 1-5.

**Person responsible:**
Risto Vuonthoemi, Aarno Pärssinen.

**Working life cooperation:**
No

**Other information:**
- 

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**521388S: Antennas, 5 cp**

**Validity:** 01.08.2015 -

**Form of study:** Advanced Studies

**Type:** Course

**Unit:** Electrical Engineering DP

**Grading:** 1 - 5, pass, fail

**Teachers:** Markus Berg

**Opintokohteen kielet (E):** English

**Leikkaavuudet (E):**

<table>
<thead>
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<th>Code</th>
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<tr>
<td>521380S-01</td>
<td>Antennas, partial credit</td>
<td>0.0 cp</td>
</tr>
<tr>
<td>521380S-02</td>
<td>Antennas, partial credit</td>
<td>0.0 cp</td>
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**ECTS Credits:**
5 ECTS credits / 135 hours of work

**Language of instruction:**
English

**Timing:**
Spring, period 4

**Learning outcomes:**
After completing the course, student

1. knows antenna terminology and understands the role of antennas as a part of different radio systems.
2. is familiar with the theories explaining the electromagnetic radiation of usual antenna types and antenna arrays.

3. will be able to design wire antennas, micro strip antennas and antenna arrays for different radio systems.

4. will be able to design and analyze various antenna types and arrays using 3D electromagnetic simulation software.

Contents:

Mode of delivery:
Face-to-face teaching

Learning activities and teaching methods:
Lectures and exercises 40 h / Compulsory antenna design work with an electromagnetic simulation 25 h / Self-study 70 h

Target group:
1st or 2nd year M.Sc. and WCE students

Prerequisites and co-requisites:
The required prerequisite is the completion of the following courses prior to enrolling for the course: Basics of Radio Engineering 521384A

Recommended optional programme components:
The course is an independent entity and does not require additional studies carried out at the same time.

Recommended or required reading:

Assessment methods and criteria:
The course is passed with a final examination and the accepted design work report. In the final grade of the course, the weight for the examination is 0.5 and that for the design work 0.5. Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible:
Markus Berg

Working life cooperation:
No

Other information:

521089S: Printed Electronics, 5 cp

Validity: 01.08.2015 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Tapio Fabritius

Opintokohteen kielet (E): Finnish

Leikkaavuudet (E):

- 521217S  Printed Electronics  4.0 cp
- 521095S  Advanced Course of Printed Electronics  3.0 cp

ECTS Credits:

5

Language of instruction:

Finnish. English if more than two international students in the course.

Timing:

Period 3.

Learning outcomes:

1. Knows the most typical materials and printing methods suitable for their processing
2. Can explain the principles of materials and printing methods
3. Can utilize the material and manufacturing process knowledge to design fabrication processes for electrical components
4. Can analyse how the selected materials and printing methods influence on the performance of electrical components

Contents:

Materials (conductive and semi-conductive polymers, photoactive polymers, dielectrics, particle based inks) and processing methods (screen printing, gravure printing, flexo printing, inkjet) utilized in printed electronics, surface wetting and film formation, printed electrical components (passive components, solar cells, light emitting diodes, transistors) and their fabrication. Possibilities and challenges of printing based processing methods and how to take them into account in the printed electronics fabrication.

Mode of delivery:

Face-to-face teaching.

Learning activities and teaching methods:

Combined lectures and exercises 30 h and self-study 100 h

Target group:

Primarily for the students of electrical engineering

Prerequisites and co-requisites:

None.

Recommended optional programme components:

The course is an independent entity and does not require additional studies carried out at the same time

Recommended or required reading:

D.R. Gamota, P. Brazis, K. Kalyanasundaram and J. Zhang, "Printed organic and molecular electronics", handout

Assessment methods and criteria:

Course is completed by final examination.

Grading:

The course unit utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible:

Tapio Fabritius

Working life cooperation:

Not included.
521124S: Sensors and Measuring Techniques, 5 cp

**Form of study:** Advanced Studies
**Type:** Course
**Unit:** Electrical Engineering DP
**Grading:** 1 - 5, pass, fail
**Teachers:** Alexey Popov, Aliaksandr Bykau
**Opintokohteen kielet (E):** Finnish

**ECTS Credits:**
5

**Language of instruction:**
English.

**Timing:**
Period 2.

**Learning outcomes:**
After the course the student is capable to explain the operating principles of different sensors and can select a right sensor for each measuring target. He/she is able to quantify the requirements that affect sensor selection as well as recognize and evaluate the uncertainty of a measurement. In addition the student is able to plan and design sensor signal conditioning circuits.

**Contents:**
Methods for measuring displacement, velocity, acceleration, torque, liquid level, pressure, flow, humidity, sound and temperature. Ultrasound, optical and nuclear measurement techniques and applications, material analyses such as pH measurement and gas concentration, pulp and paper measurements and smart sensors.

**Mode of delivery:**
Pure face-to-face teaching.

**Learning activities and teaching methods:**
Lectures 26h, exercises 12h and self-study 100h.

**Target group:**
4 year students.

**Prerequisites and co-requisites:**
No.

**Recommended optional programme components:**
No.

**Recommended or required reading:**

**Assessment methods and criteria:**
The course is passed by a final exam and passed exercises. Read more about assessment criteria at the University of Oulu webpage.

**Grading:**
1-5

**Person responsible:**
Aliaksandr Bykau ja Alexey Popov

**Working life cooperation:**
No.
521098S: Testing Techniques of Electronics and Printed Electronics, 5 cp

Validity: 01.08.2015 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Tapio Fabritius
Opintokohteen kielet (E): Finnish

ECTS Credits:
5

Language of instruction:
Finnish. English, if there are more than 2 foreign students.

Timing:
Period 4.

Learning outcomes:
1. After completing the course the student is able to analyze different kinds of testing strategies, and is able to enhance the testability of electronics through the use of design for testability.
2. The student can also compare different testing techniques of analogue and digital electronics, which have been implemented using either embedded testing methods or external automatic testing equipment.
3. Additionally, the student is able to analyze tests made using an automatic test instrument, compare different test interfaces and data busses, and recognizes principles of design of a high-quality printed test circuit board.
4. The Student understands the specific features of printed electronics having an influence on electronics testing and reliability.

Contents:
Overview of different testing methods, constructions of testers, test fixtures, test signal generation and measurement, mixed-signal test buses, DC- and parametric measurements, dynamic tests, AD/DA converter tests, DSP-based tests, data analysis, embedded testing, design for testability, Boundary scan, test applications.

Mode of delivery:
Face-to-face teaching.

Learning activities and teaching methods:
Lectures 26h/Exercises 14h and self-studying 100 h.

Target group:
Course is compulsory for the Electrical engineering students in the advanced module of Testing techniques and printed electronics.

Prerequisites and co-requisites:
The recommended prerequisite is the completion of the following courses prior to enrolling for the course unit: Electronics Design I, Electronic Measurement Techniques.

Recommended optional programme components:
This course compensates 521098S Testing Techniques of Electronics if the student hasn’t got credits from it.

Recommended or required reading:
M. Burns, G. W. Roberts: An Introduction to Mixed-Signal IC Test and Measurement, Lecture slides. Additional material will be announced at the beginning of the course.
Assessment methods and criteria:
Exam and passed lab exercises. Read more about assessment criteria at the University of Oulu webpage.

Grading:
Grade is based on exam and grade is on numerical scale 1-5.

Person responsible:
Tapio Fabritius

Working life cooperation:
No.

521328A: Simulations and Tools for Telecommunications, 5 cp

Validity: 01.08.2015 -
Form of study: Intermediate Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Johanna Vartiainen

Opintokohteen kielet (E): Finnish
Leikkaavuudet (E):
  521369A  Simulations and Tools for Telecommunications  3.0 cp
  521369A-01 Simulations and Tools for Telecommunications, exam  0.0 cp
  521369A-02 Simulations and Tools for Telecomm. exercise  0.0 cp

ECTS Credits:
5

Language of instruction:
Finnish

Timing:
Fall, period 2

Learning outcomes:
1. A student recognizes problems and limitations related to simulations.
2. She/he can select a suitable simulation method and knows how to validate the model.
3. Student knows how to generate signals, random numbers and noise.
4. She/he knows how to model fading channels.
5. A student knows how to make Monte-Carlo simulations at the baseband level and can estimate confidence level of simulation results.
6. She/he can explain principles of network level simulations.
7. A student knows basics of one or two fundamental simulation programs

Contents:
Simulation methods, modelling communication systems with simulations, confidence limits of simulation, noise generation and modelling of fading channel. A simple baseband simulation example. Basics of MATLAB and OPNET simulation software (these could vary depending on needs/availability).
Mode of delivery:
Face-to-face teaching

Learning activities and teaching methods:
Lectures 24 h (including program introductions), and the compulsory assignment with a simulation program (40 h).

Target group:
3rd year bachelor's degree students and M.Sc. students

Prerequisites and co-requisites:
Telecommunication Engineering

Recommended optional programme components:
The course is an independent entity and does not require additional studies carried out at the same time.

Recommended or required reading:

Assessment methods and criteria:
The course is passed with a final examination and the accepted simulation work report. The final grade is based on exam.
Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course unit utilizes a numerical grading scale 1-5.

Person responsible:
Johanna Vartiainen

Working life cooperation:
No

Other information:

477624S: Control System Methods, 5 cp

Validity: 01.08.2015 -
Form of study: Advanced Studies
Type: Course
Unit: Field of Process and Environmental Engineering
Grading: 1 - 5, pass, fail
Teachers: István Sele
Opintokohteen kielet (E): Finnish
Leikkaavuudet (E):

477614S Control System Methods 3.0 cp
477605S Digital Control Theory 4.0 cp

ECTS Credits:
5 ECTS / 135 hours of work

Language of instruction:
Finnish (available in English as a book exam: students will receive materials to study and take an final exam based on those materials)
Timing:
Period 1 (autumn term)

Learning outcomes:
After completing the course students can identify the problems of the sampled data systems, and know how to apply discrete time methods for systems analysis and control design.

Contents:

Mode of delivery:
Face-to-face teaching

Learning activities and teaching methods:
Lectures and exercises include guided computer simulations

Target group:
M.Sc. students in process and environmental engineering

Prerequisites and co-requisites:
The courses 477621A Control system analysis and 477622A Control system design recommended beforehand

Recommended optional programme components:
-

Recommended or required reading:

Assessment methods and criteria:
Final written exam; to request an exam in English, contact the lecturer via email beforehand.

Grading:
Numerical grading scale 1-5 or fail

Person responsible:
University teacher Seppo Honkanen

Working life cooperation:
No

Other information:
-

521279S: Signal Processing Systems, 5 cp

Validity: 01.08.2012 -
Form of study: Advanced Studies
Type: Course
Unit: Computer Science and Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Pekka Sangi
Opintokohteen kielet (E): Finnish

ECTS Credits:
5 ECTS cr

Language of instruction:
English

Timing:
Autumn, period 2

Learning outcomes:
1. Student can explain the challenges of signal processing hardware, software, and design methodologies.
2. Student is able to transform a digital filter designed with floating point arithmetic into a fixed point precision implementation, optimizing the word lengths to achieve the performance specifications.
3. Student is able to explain the most important algorithm implementation structures and can identify their usage contexts.
4. Student has rudimentary practical skills in modeling, designing, and judging finite word length signal processing algorithms with Matlab and Simulink software tools.

Contents:
Binary and floating point arithmetic, DSP programming models and co-design, digital signal processors, algorithms and implementations, including CORDIC, transforms (FFT and DCT), multi-rate signal processing, polyphase filters, filter banks, adaptive algorithms and applications. The software environments of the course are Matlab with the Fixed Point Toolbox extension and Simulink with the DSP Blockset extension.

Mode of delivery:
Lectures, independent work, group work.

Learning activities and teaching methods:
The course consists of lectures (30 h) and design exercises (6-12 h), the rest as independent work (33h).

Target group:
Computer Science and Engineering students: This is an advanced-level course intended for masters-level students, especially to those that are specializing into signal processing. + Other Students of the University of Oulu.

Prerequisites and co-requisites:
521337A Digital Filters, 521267A Computer Engineering or 521286A Computer Systems, 8 ECTS cr or 521287A Introduction to Computer Systems, 5 ECTS cr

Recommended optional programme components:
The course is an independent entity and does not require additional studies carried out at the same time.

Recommended or required reading:
Lecture notes and exercise materials. Material is in English.

Assessment methods and criteria:
Grading is based on the evaluation of the design exercises, which are done during the course, and exams, which are arranged during the lectures.
Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course unit utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible:
Pekka Sangi
Working life cooperation:
None.

521281S: Application Specific Signal Processors, 5 cp

Validity: 01.08.2012 -
Form of study: Advanced Studies
Type: Course
Unit: Computer Science and Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Olli Silven
Opintokohteen kielet (E): English

ECTS Credits:
5 ECTS credits / 135 hours of work
Language of instruction:
English.
Timing:
Autumn, period 1
Learning outcomes:
After completing the course, student
1. Can distinguish the main types of signal processors
2. Can design basic customized transport triggered architecture processors
3. Is capable of assembling a signal processor out of basic entities
4. Can match the processor performance and the application requirements
5. Applies the TTA codesign environment and Altera's FPGA tools to synthesize a system

Contents:
Examples of modern signal processing applications, main types of signal processors, parallel signal processing, transport triggered architectures, algorithm-architecture matching, TCE design environment and Altera FPGA tools.

Mode of delivery:
Lectures, exercises, independent work, group work.
Learning activities and teaching methods:
Lectures 12h (participation mandatory); Instructed labs 12h. Independent work 111h
Target group:
Computer Science and Engineering students + other Students of the University of Oulu. This is an advanced-level course intended for masters-level students and post-graduate students, especially to those who are specializing into signal processing.

Prerequisites and co-requisites:
521267A Computer Engineering or 521286A Computer Systems (8 ECTS cr) or 521287A Introduction to Computer Systems (5 ECTS cr) and 521337A digital filters, programming skills

Recommended optional programme components:
The course is an independent entity and does not require additional studies carried out at the same time.

Recommended or required reading:
Handouts.

Assessment methods and criteria:
Participation in mandatory classes and approved lab exercises and project works.
Grading:
Numerical grading scale 1-5; zero stands for a fail.

Person responsible:
Mehdi Safarpour

Working life cooperation:
No.

812341A: Object-Oriented Programming, 5 cp

Validity: 01.08.2015 -
Form of study: Intermediate Studies
Type: Course
Unit: Information Processing Science DP
Grading: 1 - 5, pass, fail
Teachers: Ilkka Räsänen

Opintokohteen kielet (E): Finnish
Leikkaavuudet (E):

ECTS Credits:
5 ECTS credits / 133 hours of work.

Language of instruction:
Finnish

Timing:
The course is held in the spring semester, during period 3. It is recommended to complete the course in
the 1st spring semester.

Learning outcomes:
• After completing the course, the student is able to explain the general objectives and techniques of
object-oriented programming paradigm.
• Furthermore, the student can describe the practical meaning of concepts of object-oriented
programming.
• The student can construct Java programs that apply inheritance, composition, and polymorphism.

Contents:
Introduction to object-orientation, Basics of programming in Java language, Composition, inheritance
and polymorphism, Java collections and exception handling.

Mode of delivery:
Face-to-face teaching.

Learning activities and teaching methods:
Lectures 32 h, laboratory exercises 21 h, weekly assignments and independent work 82 h.

Target group:
BSc students.

**Prerequisites and co-requisites:**
Course Introduction to Programming or similar knowledge.

**Recommended or required reading:**
- Timothy Budd: Introduction to object-oriented programming, 3rd edition.
- Bruce Eckel: Thinking in Java 3rd edition or later.

**Assessment methods and criteria:**
Weekly assignments (preferred) or final exam + programming assignment.

**Grading:**
Numerical scale 1-5 or fail.

**Person responsible:**
Ilkka Räsänen

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**H451226: Module of the Option, Electronics Materials and Components, 60 - 80 cp**

**Validity:** 01.08.2011 -
**Form of study:** Other Entity
**Type:** Study module
**Unit:** Electrical Engineering DP
**Grading:** 1 - 5, pass, fail

**Opintokohteen kielet (E):** Finnish

No course descriptions.

*Compulsory*

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**A451222: Module of the Option, Electronics Materials and Components, 35 - 41 cp**

**Validity:** 01.08.2005 -
**Form of study:** Module of the Option
**Type:** Study module
**Unit:** Electrical Engineering DP
**Grading:** 1 - 5, pass, fail

**Opintokohteen kielet (E):** Finnish

No course descriptions.

*Module of the Option, Compulsory studies, 41 ECTS cr (Note: 521028S Small/medium power energy harvesting and storage devices will be lectured in odd years (-19, -21, ...))*

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**521401S: Electronics Design II, 6 cp**

**Validity:** 01.08.2017 -
**Form of study:** Advanced Studies
**Type:** Course
**Unit:** Electrical Engineering DP
**Grading:** 1 - 5, pass, fail

**Teachers:** Ilkka Nissinen, Jan Nissinen
Opintokohteen kielet (E): English

ECTS Credits:
6 ECTS

Language of instruction:
In Finnish (In English if needed).

Timing:
Autumn, period 1

Learning outcomes:
Student
1. should be able to explain the structures and operating principles of the passive and active (BJT and MOS) components available for use in modern IC technologies
2. should be able to analyze and design integrated electronic blocks based on these components, such as operational amplifiers, comparators and sampling circuits
3. should be able to estimate and minimize the effects of noise in electrical circuits
4. should be able to explain the terminology used with DA and AD conversion and converters
5. should be able to analyze and outline the main architectural principles and also to evaluate the characteristics of DA and AD converters

Contents:
Modeling of BJT and MOS transistors, CMOS and BJT building blocks especially as IC-realizations, noise and analysis of noise, internal structure of operational amplifiers, critical parameters, comparators, S/H-circuits, structures and properties of A/D and D/A converters.

Mode of delivery:
Face-to-face teaching

Learning activities and teaching methods:
Face-to-face teaching: Lectures 30h, exercises 20h. Self study: a small design work 30h. Learning without guidance either privately or in a group 80h.

Target group:
Students of Electrical engineering. Other students of the University of Oulu may also participate.

Prerequisites and co-requisites:
Principles of electronics design, Electronics design I

Recommended optional programme components:

Recommended or required reading:

Assessment methods and criteria:
The course unit is passed by a final exam or by a two midterm exams and a passed design work. Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course unit utilizes a numerical grading scale 1-5.

Person responsible:
Ilkka Nissinen

Working life cooperation:
No

Other information:
-
**521124S: Sensors and Measuring Techniques, 5 cp**

**Form of study:** Advanced Studies  
**Type:** Course  
**Unit:** Electrical Engineering DP  
**Grading:** 1 - 5, pass, fail  
**Teachers:** Alexey Popov, Aliaksandr Bykau  
**Opintokohteen kielet (E):** Finnish

**ECTS Credits:**  
5

**Language of instruction:**  
English.

**Timing:**  
Period 2.

**Learning outcomes:**  
After the course the student is capable to explain the operating principles of different sensors and can select a right sensor for each measuring target. He/she is able to quantify the requirements that affect sensor selection as well as recognize and evaluate the uncertainty of a measurement. In addition the student is able to plan and design sensor signal conditioning circuits.

**Contents:**  
Methods for measuring displacement, velocity, acceleration, torque, liquid level, pressure, flow, humidity, sound and temperature. Ultrasound, optical and nuclear measurement techniques and applications, material analyses such as pH measurement and gas concentration, pulp and paper measurements and smart sensors.

**Mode of delivery:**  
Pure face-to-face teaching.

**Learning activities and teaching methods:**  
Lectures 26h, exercises 12h and self-study 100h.

**Target group:**  
4 year students.

**Prerequisites and co-requisites:**  
No.

**Recommended optional programme components:**  
No.

**Recommended or required reading:**  

**Assessment methods and criteria:**  
The course is passed by a final exam and passed exercises.  
Read more about [assessment criteria](#) at the University of Oulu webpage.

**Grading:**  
1-5

**Person responsible:**  
Aliaksandr Bykau ja Alexey Popov  

**Working life cooperation:**  
No.
521326S: Radio Engineering 1, 5 cp

Validity: 01.08.2015 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Aarno Pärssinen, Risto Vuohloniemi
Opintokohdeenteen kielet (E): Finnish
Leikkaavuudet (E):
- 521326S-01 Radio Engineering 0.0 cp
- 521326S-02 Exercise work, Radio engineering 1 0.0 cp
- 521335S-01 Radio engineering, partial credit 0.0 cp
- 521335S-02 Radio engineering, partial credit 0.0 cp
- 521335S Radio Engineering 6.0 cp

ECTS Credits:
5
Language of instruction:
English
Timing:
Fall, period 2
Learning outcomes:
1. learns key components of radio transceivers used in wireless communications including LTE and 5G.
2. knows different kind of impedance matching methods and can design the impedance matching network using lumped components and microstrip lines. A student can also explain factors, which are limiting the bandwidth of impedance matching networks. Smith chart (admittance/impedance chart).
3. will be able to design a low noise RF amplifier. The amplifier is designed that the noise figure is minimized or the gain is maximized. The impedance matching can also be made for the constant gain.
4. knows single sideband and double sideband noise in mixers. A student will be able to design balanced and double balanced mixer and knows the advantages and the disadvantages of these mixers.
5. will be able to design passive microwave components like a Wilkinson power divider, a directional coupler and hybrids.
6. can explain basic principles of RF-oscillators. A student can design a cross-coupled oscillator and voltage controlled oscillator.
7. knows concept of noise, non-linearity and dynamic range as used in radio frequency communications.
8. can classify power amplifiers and will be able in the basic case design the matching network for a power amplifier.

Contents:
Noise, non-linearity, impedance matching using lumped components, microstrip matching networks, low noise amplifier (LNA) design, active and passive mixers design, Wilkinson power dividers, directional couplers, hybrids, automatic gain control (AGC), cross-coupled oscillator, voltage controlled oscillators, power amplifier design.

Mode of delivery:
Face-to-face teaching
Learning activities and teaching methods:
Lectures 24 h, exercises 16 h and the compulsory RF design work with ADS simulation software (20 h).

Target group:
1st year M.Sc. and WCE-RF students. 2nd year M.Sc. (Telecom.) and WCE-RAN students.

Prerequisites and co-requisites:
Basics of Radio Engineering

Recommended optional programme components:
-

Recommended or required reading:

Assessment methods and criteria:
The course is passed with a final examination and the accepted simulation work report. In the final grade of the course, the weight for the examination is 0.75 and that for the simulation work 0.25. Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course unit utilizes a numerical grading scale 1-5.

Person responsible:
Risto Vuotoniemi, Aarno Pärssinen.

Working life cooperation:
No

Other information:
-

521028S: Small/Medium Power Energy Harvesting and Storage Devices, 5 cp

Validity: 01.08.2019 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Yang Bai
Opintokohteen kielet (E): Finnish

ECTS Credits:
5

Language of instruction:
English

Timing:
The course is held in the period 1 biannually. The next course will be held in autumn 2019.

Learning outcomes:
1. The students will understand the energy requirements and design principles of self-powered and autonomous electronic systems for various sensing applications.
2. The students will understand different energy harvesting and conversion techniques and thus be able to select appropriate methods according to available energy sources in defined application cases.
3. The students will understand the materials, fabrication processes and characterization methodologies of different energy harvesters and corresponding sensor systems.

4. The students will understand advanced energy storage options used for autonomous systems.

5. The students will be able to design and fabricate their own self-powered electronic devices for autonomous and ubiquitous sensing based on their own selections of application areas.

**Contents:**

Wireless devices and sensor networks; Solar, kinetic, thermal and electromagnetic wave energy harvesting; Power management circuitry and energy storage; Component and system fabrication and characterization; Hands on learning – private demonstrator manufacturing and testing.

**Mode of delivery:**

The course will be implemented as face-to-face teaching and experimental practice.

**Learning activities and teaching methods:**

The implementation methods of the course vary. The course will be arranged utilizing activating teaching methods agreed on together with the students. There will be 30 hours of guided teaching events and 102.5 hours of teaching without guidance either privately or in a group.

**Target group:**

Master's level students.

**Prerequisites and co-requisites:**

The recommended prerequisite is to familiarize with the course 521104P Introduction to Materials Physics.

**Recommended optional programme components:**

In-depth investigation of novel energy harvesters and integrated self-powered sensor systems.

**Recommended or required reading:**

Required:
Lecture notes;

Recommended (optional):

**Assessment methods and criteria:**

Final exam.
Read more about assessment criteria at the University of Oulu webpage.

**Grading:**

The final exam utilizes a numerical grading scale 1-5.

**Person responsible:**

Bai Yang

**Working life cooperation:**

No.
ECTS Credits: 5

Language of instruction: Finnish

Timing: 3rd period

Learning outcomes:
1. Upon completing the course student can explain how electronics packaging technology has since invention of transistors to current date, and can estimate how this development is going to continue in future.

2. The student can describe can explain what is meant by microjoining techniques and what are the pros and cons of these.

3. The student can tell what different kind of materials, and why, are used in IC packaging technology.

4. The student can explain what is meant with system level packaging and how the strong miniaturization on IC requires new system level packaging techniques to be developed.

5. He can explain why active and passive components are being, more and more, embedded to be a part of the circuit board.

6. In addition he can explain why and how optoelectronics will be migrate towards circuit board and components on it.

Contents:

Mode of delivery:
Face to face teaching

Learning activities and teaching methods:
Lecturing 24 h, practical work 12 h.

Target group:
Primarily major students of electrical engineering.

Prerequisites and co-requisites:
Recommended Introduction to Microfabrication Techniques.

Recommended optional programme components:
The course is an independent entity and does not require additional studies carried out at the same time.

Recommended or required reading:

Assessment methods and criteria:
The course is completed with the final exam and finished course work.

Grading:
The course unit utilizes a numerical grading scale 1-5.
Person responsible:
Sami Myllymäki

Working life cooperation:
No

Other information:

521074S: Microelectronics and Micromechanics, 5 cp

Validity: 01.08.2015 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Krisztian Kordas

Opintokohteen kielet (E): English
Leikkaavuudet (E):
- 521224S Microelectronics and Micromechanics 6.0 cp
- 521224S-01 Microelectronics and Micromechanics, exam 0.0 cp
- 521224S-02 Microelectronics and Micromechanics, exercise 0.0 cp

ECTS Credits:
5
Language of instruction:
English
Timing:
3rd period
Learning outcomes:
Objective: The course provides advanced knowledge on the semiconductor techniques of VLSI and on special topics of micromechanics and hybrid fabrication. Especially recent progress on the field is introduced in application point of view.

Learning outcomes: After completing the course the student can give account on correlations between basic physics/chemistry and materials processing/technology in microelectronics, micromechanics and nanotechnology. The student can describe design aspects and operation principles of micro and nano-devices. The students get acquainted with working in laboratory environment similar to those in academic and industrial research labs. Laboratory work practice on either (i) thin film fabrication in clean room, (ii) inkjet printing and electrical characterization of thin film devices with nanoparticles or (iii) synthesis of carbon nanotubes and characterization by electron microscopy techniques will provide a good opportunity also to learn how to design and run experiments safely and manage laboratory reports.

Contents:
Theory and practice of VLSI semiconductor fabrication technologies to support and deepen the understanding of general fabrication and operation principles introduced during previous courses. The state-of-the-art semiconductor devices and circuits: pushing the limits of dimensions and speed. Implementation of VLSI technologies in fabrication of components for micromechanics. Sensors (flow, pressure) and actuators (valves, pumps, motors, switches and components for micro-optics) using MEMSs. Devices on the nanoscale and integration of nanomaterials in microsystems: new concepts of design, fabrication and operation.

Mode of delivery:
Lectures, laboratory exercise with supervision and guidance.
Learning activities and teaching methods:
Though the course is primarily based on lectures, the communication channel is open in both directions enabling continuous comments, questions and feedback from the students. Critical explanations and think alouds are also applied to motivate thinking and active learning.

Target group:
Students of the University of Oulu.

Prerequisites and co-requisites:
Passing the basic course “521070A Introduction to microfabrication techniques” before the advanced course is recommended.

Recommended optional programme components:
-

Recommended or required reading:
Lecture notes and references therein.

Assessment methods and criteria:
Examination and completion of both laboratory exercise and report. Read more about assessment criteria at the University of Oulu webpage.

Grading:
Numerical grading 1-5.

Person responsible:
Krisztian Kordas

Working life cooperation:
-

Other information:
-

521225S: RF Components and Measurements, 5 cp

Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Teirikangas, Merja Elina

Opintokohteen kielet (E): Finnish

ECTS Credits:
5 ECTS credits / 132,5 hours of work

Language of instruction:
Finnish. English, if there are at least 3 international students in class.

Timing:
The course is held in the 4th period. It is recommended to complete the course during Master level studies.

Learning outcomes:
1. After completing the course the student has knowledge of the behavior of passive components at RF frequencies, knows the fabrication methods of components and is also able to apply the knowledge to practical applications.

2. The student also knows the operating principles of transfer lines, antennas and filters and of their design.
3. The student can apply the fundamentals of RF and microwave techniques to measurements, is able to make the measurements of RF components, has knowledge of the operating principles of RF region measurement equipment and is able to compare the usability of different equipment.

4. The student knows how to perform typical measurements of RF region magnitudes (power, frequency, impedance and noise).

Contents:
Fundamentals of RF and microwave techniques, components in microwave circuits, measurement instruments, measuring of power, frequency, impedance and noise, time-domain and active circuit measurements.

Mode of delivery:
Face-to-face teaching, independent design exercises and laboratory exercises.

Learning activities and teaching methods:
Lectures 24 h, design exercises 20 h, laboratory exercises 20 h, independent work 68.5 h.

Target group:
Masters students on electrical engineering

Prerequisites and co-requisites:
The recommended prerequisite is the completion of the following courses prior to enrolling for the course unit: Electronic Components and Materials, Electronic Measurement Techniques, Basics of Radio Engineering.

Recommended optional programme components:
The course is an independent entity and does not require additional studies carried out at the same time.

Recommended or required reading:

Assessment methods and criteria:
Final exam, design exercises and laboratory exercises.
Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible:
Merja Teirikangas

Working life cooperation:
No.

Other information:

521215S: Microelectronics project, 5 cp

Validity: 01.08.2017 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Jari Juuti
Opintokohteen kielet (E): Finnish
ECTS Credits:
5 ECTS credits / 132.5 hours of work

Language of instruction:
Finnish or English

Timing:
The course is held in the spring semester, during periods 3 and 4. It is recommended to complete the course at the 4th spring semester (1. year of MSc studies)

Learning outcomes:
After completing the course, the student
1. Is able to carry out all the stages needed to develop electronics components or materials beginning from design the material or component to realization and characterization.
2. Student is able to use independently professional and research methods, software, equipment and tools.
3. Student is able to do technical documentation of the work and keep laboratory work book during the work.

Contents:
Independent manufacturing, design, characterization or modelling work for electronics materials or components.

Mode of delivery:
Face-to-face teaching

Learning activities and teaching methods:
Project work for 132.5 hours

Target group:
Masters students on Electrical engineering

Prerequisites and co-requisites:
Bachelors degree in electrical engineering or equivalent.

Recommended optional programme components:
The course is an independent entity.

Recommended or required reading:
Given in the beginning of the course.

Assessment methods and criteria:
Project work is assessed by the achievement of the project targets and quality of the report.

Grading:
The course utilizes verbal grading scale “Laudatur/pass/fail”.

Person responsible:
Jari Juuti

Working life cooperation:
Some of the project work can be made in cooperation with companies.

Other information:

A451291: Advanced Module, Electronics Materials and Components, 10 - 52 cp

Validity: 01.08.2015 -
Form of study: Advanced Module
Type: Study module
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Opintokohteen kielet (E): Finnish

No course descriptions.

Advanced module, Obligatory courses 20 ECTS cr

521080S: X-ray Diffraction, 5 cp

Validity: 01.08.2015 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Juha Hagberg
Opintokohteen kielet (E): Finnish

ECTS Credits:
5 ECTS credits / 132,5 hours of work

Language of instruction:
Finnish, English if needed

Timing:
Autumn semester period 2. Lectured every other year.

Learning outcomes:
1. explain the general principles of interaction between X-rays and solid matter and the physics underlying behind these phenomena

2. explain how the crystal structure, phase ratio, grain size and stress state in a solid material with X-ray diffraction (XRD) method can be experimentally determined

Contents:

Mode of delivery:
Lectures, exercises and laboratory work.

Learning activities and teaching methods:
Lectures and exercises altogether 32 h / laboratory work 18 h / self-access writing of work report 30 h / self-access learning 52,5 h.

Target group:
Primarily for students in Electronics and Communications Engineering.

Prerequisites and co-requisites:
Basic physics and mathematics.

Recommended optional programme components:
The course is an independent entity and does not require additional studies carried out at the same time.

Recommended or required reading:
Assessment methods and criteria:
Final grade of the course will be a weighted average of theoretical examination (2/3) and laboratory exercises (1/3).
Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible:
Juha Hagberg

Working life cooperation:
No

Other information:
The course is held next in autumn 2019.

521072S: Microsensors, 5 cp

Validity: 01.08.2015 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Jari Hannu
Opintokohteen kielet (E): Finnish
Leikkaavuudet (E):
   521228S Microsensors 4.0 cp

ECTS Credits:
5 ECTS credits / 132,5 hours of work

Language of instruction:
English. Guidance and exams also possible in Finnish.

Timing:
The course is held in the 2nd period. Teaching is available every second year. The next time course is arranged on autumn 2020.

Learning outcomes:
1. After completing the course, student can explain the basic concepts of sensor theory and technology, classification of sensors, properties of ideal and real sensors, pros and cons of integrated smart sensor systems, and the interface between sensor and pro

2. Student can explain the main fabrication methods, including thin-film technologies, micromachining methods, wet and dry etching techniques, and both laser and ion beam milling methods and their applications in microsensor fabrication.

3. Students can explain the basic structures, physical operation principles, and fabrication processes of main sensor types for different forms of energy.

Contents:
The principles of microsensors, physical magnitudes which can be measured and manufacturing technologies for microsensors.

Mode of delivery:
Blended teaching (web-based and face-to-face teaching).

Learning activities and teaching methods:
The course will be arranged utilizing activating teaching methods agreed on together with the students. There will be 14 hours of guided teaching events and 118.5 hours of teaching with web-based guidance either privately or in a group.

**Target group:**
Master students in electrical engineering.

**Prerequisites and co-requisites:**
Recommended prerequisite is Bachelors degree in Electrical Engineering.

**Recommended optional programme components:**
The course is an independent entity and does not require additional studies carried out at the same time.

**Recommended or required reading:**
Will be informed at the beginning of the course.

**Assessment methods and criteria:**
This course utilizes continuous assessment. The method will be informed at the beginning of the course.

**Grading:**
The course utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

**Person responsible:**
Jari Hannu

**Working life cooperation:**
No

**Other information:**
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521079S: Introduction to Nanotechnology, 5 cp

**Validity:** 01.08.2015 -

**Form of study:** Advanced Studies

**Type:** Course

**Unit:** Electrical Engineering DP

**Grading:** 1 - 5, pass, fail

**Teachers:** Krisztian Kordas

**Opintokohteen kielet (E):** Finnish

**ECTS Credits:**
5

**Language of instruction:**
English

**Timing:**
4th period

**Learning outcomes:**
1. The students will acquire the basic principles of nanoscience and technology.

2. The course will also help understanding and rational thinking concerning strategies towards practical synthesis and safe utilization of nanomaterials.

**Contents:**
Nanotechnology definitions and the nanomaterials around us. Health concerns. Synthesis methods; morphological, structural, electrical, optical and spectroscopic characterization of

**Mode of delivery:**
Lectures

**Learning activities and teaching methods:**
Though the course is primarily based on lectures, the communication channel is open in both directions enabling continuous comments, questions and feedback from the students. Critical explanations and think alouds are also applied to motivate thinking and active learning.

**Target group:**

**Prerequisites and co-requisites:**

**Recommended optional programme components:**

**Recommended or required reading:**

**Assessment methods and criteria:**
Examination.

**Grading:**
Numerical grading 1-5.

**Person responsible:**
Krisztian Kordas

**Working life cooperation:**

**Other information:**

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**521089S: Printed Electronics, 5 cp**

**Validity:** 01.08.2015 -

**Form of study:** Advanced Studies

**Type:** Course

**Unit:** Electrical Engineering DP

**Grading:** 1 - 5, pass, fail

**Teachers:** Tapio Fabritius

**Opintokohteen kielet (E):** Finnish

**Leikkaavuudet (E):**
- 521217S Printed Electronics 4.0 cp
- 521095S Advanced Course of Printed Electronics 3.0 cp

**ECTS Credits:**
5

**Language of instruction:**
Finnish. English if more than two international students in the course.
Timing:
Period 3.

Learning outcomes:
1. Knows the most typical materials and printing methods suitable for their processing
2. Can explain the principles of materials and printing methods
3. Can utilize the material and manufacturing process knowledge to design fabrication processes for electrical components
4. Can analyse how the selected materials and printing methods influence on the performance of electrical components

Contents:
Materials (conductive and semi-conductive polymers, photoactive polymers, dielectrics, particle based inks) and processing methods (screen printing, gravure printing, flexo printing, inkjet) utilized in printed electronics, surface wetting and film formation, printed electrical components (passive components, solar cells, light emitting diodes, transistors) and their fabrication. Possibilities and challenges of printing based processing methods and how to take them into account in the printed electronics fabrication.

Mode of delivery:
Face-to-face teaching.

Learning activities and teaching methods:
Combined lectures and exercises 30 h and self-study 100 h

Target group:
Primarily for the students of electrical engineering

Prerequisites and co-requisites:
None.

Recommended optional programme components:
The course is an independent entity and does not require additional studies carried out at the same time

Recommended or required reading:
D.R. Gamota, P. Brazis, K. Kalyanasundaram and J. Zhang, "Printed organic and molecular electronics", handout

Assessment methods and criteria:
Course is completed by final examination.

Grading:
The course unit utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible:
Tapio Fabritius

Working life cooperation:
Not included.

Recommended optional studies 26 ECTS cr or until the degree is 120 ECTS cr, see http://www.oulu.fi/ee/opiskelu/oppaat

521435S: Electronics Design III, 6 cp

Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Ilkka Nissinen

Opintokohteen kielet (E): Finnish

ECTS Credits:
6

Language of instruction:
In Finnish (English as a book examination)

Timing:
Autumn, period 2

Learning outcomes:
1. On completion of the study module students should be able to detail the advantages of differential signal processing in IC realizations and
2. to analyze and design differential amplifiers and other electronic blocks for implementation in an IC environment.
3. They should be able to explain how an SC (switched capacitor) technology functions and to apply such a technology to sampling and filtering.
4. They should also be able to describe the principles for realizing continuous filters in IC technologies, to explain the principles of the delta–sigma technology
5. and to apply it for realizing integrated DA and AD converters.
6. They should be able to account for the functioning, use and architecture of a phase-locked loop,
7. to explain the functioning of an MOS transistor in the area of weak inversion and to indicate how use can be made of this functional area in circuit design.

Contents:
Advanced operational amplifier topologies, especially differential ones, bandgap and PTAT bias circuits and references, problems related to the design of multi-stage amplifiers (output stages, LP/LV implementations), signal sampling and error sources related to it, SC-techniques (especially in filters), implementation principles of continuous time IC filters, DS techniques in general and particularly in AD/DA converters, operations with frequency/phase domain signals, design of IC layout.

Mode of delivery:
Face-to-face teaching

Learning activities and teaching methods:
Lectures 30h and Exercises 20 h and 4h layout demo. Self-study or in a group of two persons: laboratory exercise 36 h (CAD tools used in IC design and familiarization into the complete analogue IC design flow) and learning without guidance either privately or in a group 69 h.

Target group:
Electrical Engineering students and other Students of the University of Oulu.

Prerequisites and co-requisites:
Electronics Design II, Filters, Introduction to Microfabrication Techniques (recommended).

Recommended optional programme components:
The course is an independent entity and does not require additional studies carried out at the same time

Recommended or required reading:
Lecture notes
or D. A. Johns K. Martin: Analog integrated circuit design, Wiley Sons 1997 1st edition chapter 6, chapter 8 partially, 9, 10, 14, 15

Assessment methods and criteria:
Passed final exam or 2 midterm exams and exercise work. Read more about assessment criteria at the University of Oulu webpage.

**Grading:**
Numerical grading scale 1-5.

**Person responsible:**
Ilkka Nissinen

**Working life cooperation:**
No

**Other information:**
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521405A: Electronic System Design, 5 cp

**Form of study:** Intermediate Studies

**Type:** Course

**Unit:** Electrical Engineering DP

**Grading:** 1 - 5, pass, fail

**Teachers:** Kari Määttä

**Opintokohteen kielet (E):** Finnish

**ECTS Credits:**
5

**Language of instruction:**
English/Finnish.

**Timing:**
Period 1

**Learning outcomes:**
1. is able to choose the optimum method of the choices presented in the course in the field of power supply, thermal design, grounding, and routing of the high speed signals.
2. is able to calculate problems, caused by electrical disturbances, crosstalk and non-idealities of electrical components.
3. can calculate reliability of an electrical device or system.
4. The main goal of the course is to introduce methods and techniques needed in designing larger electronic entities such as equipment and systems.

**Contents:**
Power supplies, thermal design, grounding, transmission of fast signals by using transmission lines, electrical disturbances, crosstalk, non-idealities of electrical components.

**Mode of delivery:**
Face-to-face teaching.

**Learning activities and teaching methods:**
The course includes 30 h of lectures and 20 h of exercises.

**Target group:**
Primarily in electrical engineering students. Other University of Oulu students can complete the course.

**Prerequisites and co-requisites:**
Both Principles of Electronics Design and Analogue Electronics I must have been accepted.
**Recommended optional programme components:**
The course is an independent entity and does not require other studies carried out at the same time.

**Recommended or required reading:**

**Assessment methods and criteria:**
The course is passed by means of a final exam. 
Read more about assessment criteria at the University of Oulu webpage.

**Grading:**
The course unit utilizes a numerical grading scale 0 - 5. In the numerical scale 0 stands for a fail.

**Person responsible:**
Kari Määttä

**Working life cooperation:**
No.

**Other information:**

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**521406S: Digital Techniques 3, 7 cp**

**Validity:** 01.08.2017 -

**Form of study:** Advanced Studies

**Type:** Course

**Unit:** Electrical Engineering DP

**Grading:** 1 - 5, pass, fail

**Teachers:** Jukka Lahti

**Opintokohteen kielet (E):** Finnish

**ECTS Credits:**
7 ECTS

**Language of instruction:**
In Finnish. Exams can be arranged in English on demand.

**Timing:**
Spring, peridos 3-4

**Learning outcomes:**
Student
1. knows the phases of the design process of hardware parts of digital system implemented in FPGA or ASIC technologies, and understands their purpose, and the problems and aims associated with different design tasks
2. is able to use the tools needed in industrial design projects.

**Contents:**

**Mode of delivery:**
Classroom

**Learning activities and teaching methods:**

Lectures 20h/ exercises 20h (group work)/ independent work 120h.

**Target group:**

Primarily electrical and computer science and engineering students. Also other student of University of Oulu can take the course.

**Prerequisites and co-requisites:**

Digital techniques 1 and Digital techniques 2

**Recommended optional programme components:**

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**Recommended or required reading:**

Lecture textbook (in finnish) and literature announced during course.

**Assessment methods and criteria:**

Final exam and a design exercise, or weekly assignments consisting of theoretical and design exercises.

Read more about [assessment criteria](#) at the University of Oulu webpage.

**Grading:**

1-5, The grade is the average of the exam and the design exercise, or the grade of the weekly assignments.

**Person responsible:**

Jukka Lahti

**Working life cooperation:**

No

**Other information:**

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**521423S: Embedded System Project, 5 cp**

**Form of study:** Advanced Studies

**Type:** Course

**Unit:** Computer Science and Engineering DP

**Grading:** 1 - 5, pass, fail

**Teachers:** Juha Röning

**Opintokohteen kielet (E):** English

**ECTS Credits:**

5

**Language of instruction:**

Lecturing in Finnish, material available in English

**Timing:**

Spring, periods 3-4.

**Learning outcomes:**

1. After passing the course, the student is familiar with the design process of an embedded system, from specifying the application leading to the requirement specification for the device, and then to having produced a functional prototype of the defined system.

2. The student is more familiar with the roles of the client and the system developer during the requirement specification, and the role of the iterations as a part of the whole design process. From the specifications, the student is familiar with the process of choosing the suitable hardware
components, circuit design and implementation. In the end, the student is also able to know the factors arising from the SW/HW partitioning process of the actual implementation, and the concept of SW/HW dualism. The student can then better utilize the basic development tools used for embedded system design and recognize their possible advantages and disadvantages.

3. The student is more familiar with the testing and problem solving methodology related to the prototype implementation of an embedded system, to have the prototype working correctly according to the specifications.

**Contents:**
The embedded system design process, from initial specification to implementation of a first functional prototype and demonstrating its functionality in practice. The application can be suggested by the student group, or chosen from the topics suggested by the course organizers. During the work, the students familiarize themselves with modern design tools and methodologies related to embedded system design (according to the microcontroller the student group has chosen to utilize in their work). Most commonly used platforms on the course include STM, Atmel and Microchip based platforms.

**Mode of delivery:**
Lectures, face-to-face tutoring and self-study.

**Learning activities and teaching methods:**
The course is run as a project work in groups of three with progress follow-up reporting meetings. Lectures 10 h, laboratory exercise in period 3-4 120 h.

**Target group:**
Computer Science and Engineering students and other Students of the University of Oulu.

**Prerequisites and co-requisites:**
811122P Introduction to Programming
521412A Digital Techniques I
Also recommended; 521275A Embedded Software Project, 521432A Electronics Design I.

**Recommended optional programme components:**
The course is an independent entity and does not require additional studies carried out at the same time.

**Recommended or required reading:**
-

**Assessment methods and criteria:**
Project work.
Read more about assessment criteria at the University of Oulu webpage.

**Grading:**
The course unit utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

**Person responsible:**
Juha Röning

**Working life cooperation:**
None.

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**521300S: Electronics Design and Construction Exercise, 6 cp**

**Validity:** 01.08.2015 -

**Form of study:** Advanced Studies

**Type:** Course

**Unit:** Electrical Engineering DP

**Grading:** 1 - 5, pass, fail

**Teachers:** Kari Määttä
Opintokohteen kielet (E): Finnish
Leikkaavuudet (E):
   521441S   Electronics Design and Construction Exercise   6.5 cp

ECTS Credits:
6

Language of instruction:
Finnish, English

Timing:
Periods 1-4

Learning outcomes:
1 is able to carry out all the stages needed to develop an electronic circuit or device starting from independent creation and design work to realization, testing and technical documentation.
2 is able to use independently without any help professional methods, software packages, measurement devices and tools.
3 Objective: To familiarize the student with independent electrical circuit and system design and with the methods and tools used in the design process. The course prepares the student for the diploma work in the area of circuits and system design.

Contents:
Design and construction of an electronic device or a part of a device according to the given specification. The task can be part of an industrial research or a product design project or part of the research project going on in Electronics or other laboratory. The subject of the work can be own suggestion of the student or a pre-selected course subject, which enables comprehensive training of skills needed for the design of a modern electronic device.

Mode of delivery:
Independent work.

Learning activities and teaching methods:
Independent design and construction work 180h

Target group:
Primarily in electrical engineering students. Other University of Oulu students can complete the course

Prerequisites and co-requisites:
Student must have passed following courses: Analogue Electronics I-II, Digital Techniques I-II, Electronic System Design and Filter Theory.

Recommended optional programme components:
The course is an independent entity and does not require other studies carried out at the same time.

Recommended or required reading:
Not defined

Assessment methods and criteria:
The task can be carried out by a student or by a team of two students. The grade will be decided on the basis of the statement of the instructor, realization of the device and the report provided by the student.
Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course unit utilizes a numerical grading scale 0 - 5. In the numerical scale 0 stands for a fail.

Person responsible:
Kari Määttä

Working life cooperation:
521096S: Measuring Systems, 5 cp

Validity: 01.08.2015 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Juha Saarela
Opintokohteen kielet (E): Finnish
Leikkaavuudet (E):
  521110S   Measuring and Testing Systems   6.0 cp
  521110S-01 Measuring and Testing Systems, exam   0.0 cp
  521110S-02 Measuring and Testing Systems, exercise work   0.0 cp

ECTS Credits:
5 ECTS credits / 128h
Language of instruction:
Finnish. English, if there are more than 2 foreign students.
Timing:
Guided course is on period 2. The course can be completed independently in during spring semester. Ask responsible person for instructions.
Learning outcomes:
1. is able to design a multisensor measurement systems which store the measurement data.
2. is able to assembly a multisensor measurement systems which store the measurement data.
3. is able to program with LabView.
Contents:
Basics of measurement and testing systems, especially wired and wireless data transmission. Data acquisition cards. Basics of LabView programming.
Mode of delivery:
The course can be completed independently during spring semester. Ask instructions from responsible person.
Learning activities and teaching methods:
The course includes 28h lectures and guided exercises. 100 h self-studies.
Target group:
Master level students regardless of master's programme.
Prerequisites and co-requisites:
None.
Recommended optional programme components:
This course compensates earlier courses with same core content but different course code or credit named Measuring and Testing Systems.
Recommended or required reading:
Course material is in English and Finnish and can be found in Optima.
Assessment methods and criteria:
Final exam and passed laboratory works.
Read more about assessment criteria at the University of Oulu webpage.
Grading:
Grade is based on exam and grade is on numerical scale 1-5.

Person responsible:
Juha Saarela

Working life cooperation:
No.

521088S: Optoelectronics, 5 cp

Validity: 01.01.2014 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Juha Kostamovaara
Opintokohteen kielet (E): Finnish

ECTS Credits:
5
Language of instruction:
Finnish
Timing:
Autumn, period 1
Learning outcomes:
1. is able to explain the principles of operation of optical fibres and waveguides

2. is able to explain the principles of operation of semiconductor light sources and photo detectors, and knows the factors affecting their performance

3. is able to outline the circuit-level structures for optical transmitter circuits and photo detector preamplifiers

4. is able to compare their performance in terms of the main performance parameters

Contents:

Mode of delivery:
Face-to-face teaching

Learning activities and teaching methods:
Lectures 30 h and exercises 20 h, may include a seminar.

Target group:
This course is targeted mainly for the students of electrical engineering degree program, but available for other students as well.

Prerequisites and co-requisites:
Principles of semiconductor devices.

Recommended optional programme components:
This course is independent, no other components are recommended simultaneously.
Recommended or required reading:

Assessment methods and criteria:
Final exam. Read more about assessment criteria at the University of Oulu webpage.

Grading:
Numerical grading scale 1-5.

Person responsible:
Juha Kostamovaara

Working life cooperation:
Does not apply.

Other information:

521094S: Optoelectronic Sensors of Future, 5 cp

Validity: 01.08.2015 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Anssi Mäkynen
Opintokohteen kielet (E): Finnish
Leikkaavuudet (E):

521238S Optoelectronic Measurements 4.0 cp

ECTS Credits:
5

Language of instruction:
English

Timing:
Period 3

Learning outcomes:
Objective: The goal of this course is to make the student familiar with optical measurement principles, sensors and device configurations used in industrial inspection tasks.

Learning outcomes: Upon completion of the course, the student is able to explain the operating principles of the most common optical measurement methods used in industrial production, name the factors affecting their performance, design certain sensor systems and evaluate the applicability of measurement methods for various measurement tasks. Additionally he is able to independently find information and discover the operating principles of various optical measurements and to condense the collected information into written and verbal report.

Contents:

Mode of delivery:
Face-to-face teaching.
Learning activities and teaching methods:
The course includes 42 h lectures or calculation exercises and 100 h self-studies.

Target group:
4th year students

Prerequisites and co-requisites:
Completion of the course 766329A Wave Motion and Optics is recommended.

Recommended optional programme components:
Course replaces earlier by same name but different code and credit points.

Recommended or required reading:
Lecture handouts and discourse material prepared by students. Delivery through Optima.

Assessment methods and criteria:
Final exam and a passed discourse.
Read more about assessment criteria at the University of Oulu webpage.

Grading:
Numerical grading scale 1-5.

Person responsible:
Anssi Mäkynen

Working life cooperation:
No.

521098S: Testing Techniques of Electronics and Printed Electronics, 5 cp

Validity: 01.08.2015 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Tapio Fabritius

Opintokohteen kielet (E): Finnish

ECTS Credits:
5

Language of instruction:
Finnish. English, if there are more than 2 foreign students.

Timing:
Period 4.

Learning outcomes:
1. After completing the course the student is able to analyze different kinds of testing strategies, and is able to enhance the testability of electronics through the use of design for testability.
2. The student can also compare different testing techniques of analogue and digital electronics, which have been implemented using either embedded testing methods or external automatic testing equipment.
3. Additionally, the student is able to analyze tests made using an automatic test instrument, compare different test interfaces and data busses, and recognizes principles of design of a high-quality printed test circuit board.
4. The Student understands the specific features of printed electronics having an influence on electronics testing and reliability.

**Contents:**
Overview of different testing methods, constructions of testers, test fixtures, test signal generation and measurement, mixed-signal test buses, DC- and parametric measurements, dynamic tests, AD /DA converter tests, DSP-based tests, data analysis, embedded testing, design for testability, Boundary scan, test applications.

**Mode of delivery:**
Face-to-face teaching.

**Learning activities and teaching methods:**
Lectures 26h/Exercises 14h and self-studying 100 h.

**Target group:**
Course is compulsory for the Electrical engineering students in the advanced module of Testing techniques and printed electronics.

**Prerequisites and co-requisites:**
The recommended prerequisite is the completion of the following courses prior to enrolling for the course unit: Electronics Design I, Electronic Measurement Techniques.

**Recommended optional programme components:**
This course compensates 521098S Testing Techniques of Electronics if the student hasn’t got credits from it.

**Recommended or required reading:**
M. Burns, G. W. Roberts: An Introduction to Mixed-Signal IC Test and Measurement, Lecture slides. Additional material will be announced at the beginning of the course.

**Assessment methods and criteria:**
Exam and passed lab exercises. 
Read more about [assessment criteria](#) at the University of Oulu webpage.

**Grading:**
Grade is based on exam and grade is on numerical scale 1-5.

**Person responsible:**
Tapio Fabritius

**Working life cooperation:**
No.

521115S: EMC Design, 5 cp

**Validity:** 01.08.2005 -

**Form of study:** Advanced Studies

**Type:** Course

**Unit:** Electrical Engineering DP

**Grading:** 1 - 5, pass, fail

**Teachers:** Hannu Sorvoja

**Opintokohteen kielet (E):** Finnish

**Leikkaavuudet (E):**
- 521172S  EMC Design  4.0 cp
- 521172S-02  EMC Design, Exercise work  0.0 cp
- 521172S-01  EMC Design, Exam  0.0 cp
ECTS Credits: 5

Language of instruction: Finnish. English, if there are more than 2 foreign students.


Learning outcomes:
1. is able to name common EMC standards
2. is able to use EMC testing equipment and methods
3. can explain the noise coupling mechanisms
4. is able to use good design practices related to analogue and digital electronics design
5. is able to use good design practices related to analogue and digital electronics grounding
6. is able to use good design practices related to analogue and digital electronics filtering
7. is able to use good design practices related to analogue and digital electronics shielding

Contents:
EMC standards for emission and susceptibility, interference coupling, circuit design and grounding, connections, filtering, shielding, EMC testing laboratories, EMC tests and their background.

Mode of delivery:
face-to-face teaching

Learning activities and teaching methods:
The course includes 30 h lectures and 100 h self-studies.

Target group:
Primarily students studying electrical engineering. In addition, other students studying in the University of Oulu can carry out the course.

Prerequisites and co-requisites:
The recommended prerequisite is the completion of the following courses prior to enrolling for the course unit: Electronics Design I, Digital Techniques I, Electronic Measurement Techniques, Measuring and Testing Systems, RF Components and Measurements.

Recommended optional programme components:
The course replaces previous courses with same name, but different credits and code.

Recommended or required reading:

Assessment methods and criteria:
Final exam.
Read more about assessment criteria at the University of Oulu webpage.

Grading:
Grade is based on exam and grade is on numerical scale 1-5.

Person responsible:
Hannu Sorvoja
Working life cooperation:
Company visits if possible.

Other information:

521388S: Antennas, 5 cp

Validity: 01.08.2015 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Markus Berg
Opintokohteen kielet (E): English
Leikkaavuudet (E):

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<td>Antennas, partial credit</td>
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</table>

ECTS Credits:
5 ECTS credits / 135 hours of work

Language of instruction:
English

Timing:
Spring, period 4

Learning outcomes:
After completing the course, student
1. knows antenna terminology and understands the role of antennas as a part of different radio systems.
2. is familiar with the theories explaining the electromagnetic radiation of usual antenna types and antenna arrays.
3. will be able to design wire antennas, micro strip antennas and antenna arrays for different radio systems.
4. will be able to design and analyze various antenna types and arrays using 3D electromagnetic simulation software.

Contents:

Mode of delivery:
Face-to-face teaching

Learning activities and teaching methods:
Lectures and exercises 40 h / Compulsory antenna design work with an electromagnetic simulation 25 h / Self-study 70 h

Target group:
Prerequisites and co-requisites:
The required prerequisite is the completion of the following courses prior to enrolling for the course: Basics of Radio Engineering 521384A

Recommended optional programme components:
The course is an independent entity and does not require additional studies carried out at the same time.

Recommended or required reading:

Assessment methods and criteria:
The course is passed with a final examination and the accepted design work report. In the final grade of the course, the weight for the examination is 0.5 and that for the design work 0.5. Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible:
Markus Berg

Working life cooperation:
No

Other information:

521386S: Radio Channels, 5 cp

Validity: 01.08.2011 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Pekka Kyösti, Markus Berg
Opintokohteen kielet (E): English

ECTS Credits:
5 ECTS credits / 130 hours of work

Language of instruction:
English

Timing:
Autumn, period 2.

Learning outcomes:
After completing the course, student
1. will be able to define what the radio channel is and is able to distinguish it into modellable parts.
2. knows different radio wave propagation mechanisms.
3. can apply physical and empirical radio channel models.
4. is able to analyse which are the dominating propagation mechanisms in different environments.
5. will know how to measure the properties of different radio channels.

Contents:

Mode of delivery:
Face-to-face teaching

Learning activities and teaching methods:
Lectures 24 h / Exercises 12 h / compulsory laboratory work 25 h / Self-study 74 h.

Target group:
1st or 2nd year M.Sc. and WCE students

Prerequisites and co-requisites:
The required (or recommended) prerequisite is the completion of the following courses prior to enrolling for the course: Basics of Radio Engineering, Signal Analysis

Recommended optional programme components:
The course is an independent entity and does not require additional studies carried out at the same time.

Recommended or required reading:

Assessment methods and criteria:
The course is passed with a final examination and the accepted laboratory work report. Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible:
Markus Berg / Pekka Kyöstö

Working life cooperation:
No

Other information:
-

521327S: Radio Engineering II, 6 cp

Validity: 01.08.2015 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Risto Vuohtoniemi, Aarno Pärssinen
Opintokohteen kielet (E): English
Leikkaavuudet (E):
521375S  Design of Tranceivers    5.0 cp
521375S-01  Design of tranceivers, partial credit    0.0 cp
521375S-02  Exercise work, Radio Engineering II    0.0 cp

ECTS Credits:
6 ECTS cr

Language of instruction:
English

Timing:
Spring, period 3

Learning outcomes:
1. understands radio system and RF design for modern wireless equipment like cellular phones.
2. recognizes the blocks of a transceiver and can explain the operating principle of a transceiver.
3. can classify different architectures used in a single and a multi-antenna transceiver and understand the basis for them.
4. will be able to define parameters used in the transceiver system level design and can design a transceiver at the system level so that the requirements for the system are fulfilled.
5. knows nonlinear distortion and can design the automatic gain control in the system level.
6. will be able to explain factors, which are important for the selection of D/A- and A/D-converters and can derive various methods to create the in phase and the quadrature components of a received signal.
7. understands the principles of frequency synthesis in a transceiver.
8. understands principles of key implementation technologies of radio transceivers and relation to electronics.

Contents:
Designing a transceiver at the system level, transceiver architectures, performance characteristics of transceivers, nonlinearities, factors which limit the performance of a transceiver, placement of the A/D-converter in a receiver, frequency synthesis, design and implementation examples.

Mode of delivery:
Face-to-face teaching

Learning activities and teaching methods:
Lectures 32 h and the compulsory design exercise with ADS simulation software (54 h).

Target group:
1st year M.Sc. and WCE-RF students

Prerequisites and co-requisites:
Radio Engineering I

Recommended optional programme components:
-

Recommended or required reading:

Assessment methods and criteria:
The course is passed with a final examination and the accepted simulation work report. In the final grade of the course, the weight for the examination is 0.75 and that for the simulation work 0.25.
Read more about assessment criteria at the University of Oulu webpage.

**Grading:**
The course unit utilizes a numerical grading scale 1-5.

**Person responsible:**
Risto Vuohtoniemi, Aarno Pärssinen.

**Working life cooperation:**
No

**Other information:**
-

**521402S: Telecommunications Circuit Design, 6 cp**

**Validity:** 01.08.2017 -

**Form of study:** Advanced Studies

**Type:** Course

**Unit:** Electrical Engineering DP

**Grading:** 1 - 5, pass, fail

**Teachers:** Rahkonen, Timo Erkki

**Opintokohteen kielet (E):** Finnish

**ECTS Credits:**
6 ects / 42 contact hours + design exercise

**Language of instruction:**
English/Finnish

**Timing:**
Autumn, 1st period of the last year of studies

**Learning outcomes:**
After completing the course the student
- knows the most usual schematic structures and dimensioning principles of typical telecommunication circuit blocks
- can sketch the spectral effects of non-linear and time-varying circuit blocks
- can evaluate the performance of the available IC process node

**Contents:**
The course gives the background needed in the design of RFICs and other analog telecommunication circuit blocks.

**Mode of delivery:**
Face-to-face teaching

**Learning activities and teaching methods:**
28 hours of lectures, 14 of excercises, and a relatively large design task.

**Target group:**
Last year MSc students with strong analog design background

**Prerequisites and co-requisites:**
Strong background in analog transistor level design is required.

**Recommended optional programme components:**
Needs electronics design 2-3 background

**Recommended or required reading:**
Handouts
Assessment methods and criteria:
Graded based on the final exam. The design exercise needs to be passed.

Grading:
Numerical scale 0-5. 0 is fail, 5 the best.

Person responsible:
Prof. Timo Rahkonen

Working life cooperation:
The topics are strongly related to the skills needed in the industry

Other information:
The course is the last advanced course in analog design, and requires the basic knowledge of transistor level analog design and IC design.

H453221: Module of the Option, Telecommunication Engineering, 60 - 80 cp

Validity: 01.08.2011 - 
Form of study: Other Entity
Type: Study module
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Opintokohteen kielet (E): Finnish

No course descriptions.

Module of the option, Telecommunication, Obligatory Studies 40 ECTS cr

A451224: Module of the Option, Telecommunication Engineering, 40 - 41 cp

Validity: 01.08.2011 - 
Form of study: Module of the Option
Type: Study module
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Opintokohteen kielet (E): Finnish

No course descriptions.

Module of the Option. 40 ECTS cr

031051S: Numerical Matrix Analysis, 5 cp

Validity: 01.08.2012 - 
Form of study: Advanced Studies
Type: Course
Unit: Applied Mathematics and Computational Mathematics
Grading: 1 - 5, pass, fail
Teachers: Marko Huhtanen
Opintokohteen kielet (E): Finnish
**ECTS Credits:**
5 ECTS credits / 135 hours of work

**Language of instruction:**
Finnish or English.
The course can be completed in English by intermediate exams or by a final exam.

**Timing:**
Fall semester, period 1

**Learning outcomes:**
After completing the course the student knows the most efficient and numerically stable methods to solve the basic problems in linear algebra. He/she knows the basic matrix factorizations and their approximations. The student has the capability to solve very large and sparse problems with the iterative solutions methods and understands the significance of preconditioning.

**Contents:**

**Mode of delivery:**
Face-to-face teaching

**Learning activities and teaching methods:**
Lectures 28 h / Group work 14 h / Self-study 93 h.

**Target group:**

**Prerequisites and co-requisites:**
Completion of courses Calculus I and II, a course on Differential Equations and a Course on Linear Algebra and Numerical analysis

**Recommended optional programme components:**

**Recommended or required reading:**
Material posted on the web-page of the course.

**Assessment methods and criteria:**
Intermediate exams or a final exam.
Read more about [assessment criteria](#) at the University of Oulu webpage.

**Grading:**
The course utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

**Person responsible:**
Marko Huhtanen

**Working life cooperation:**

**Other information:**

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**521348S: Statistical Signal Processing 1, 5 cp**

**Validity:** 01.08.2016 -

**Form of study:** Advanced Studies

**Type:** Course

**Unit:** Electrical Engineering DP
Grading: 1 - 5, pass, fail

Teachers: Janne Lehtomäki, Juntti, Markku Johannes

Opintokohteen kielet (E): Finnish

Leikkaavuudet (E):

521484A Statistical Signal Processing 5.0 cp

ECTS Credits:

5 ECTS

Language of instruction:

English

Timing:

The course is held in the autumn semester, during period 1. It is recommended to complete the course at the 1st semester of the master studies.

Learning outcomes:

Upon completion the student
1. knows the key tools of linear algebra and optimization and can apply them in solving signal processing problems.
2. understands the key concepts in estimation theory such as the classical and Bayesian framework.
3. masters the most important estimation principles such as minimum variance, maximum likelihood, least squares and minimum mean square error estimators.
4. can derive an estimator for a given criterion and basic data models.
5. can use the methodology of estimation theory to analyze the performance of estimators.
6. understands the basics of detection and classification theory: hypothesis testing, receiver operating characteristics (ROC), matched filtering, estimator-correlator.

Contents:

Review of probability, linear algebra, random variables and stochastic processes; SVD (Singular value decomposition), QR decomposition, estimation theory, minimum variance unbiased estimator, Cramer-Rao lower bound, linear models, general minimum variance unbiased estimation, best linear unbiased estimators, maximum likelihood estimation, least squares estimation, Bayesian estimation, linear Bayesian estimation, Wiener filters, statistical decision theory, receiver operating characteristics, hypothesis testing, matched filter, estimator-correlator.

Mode of delivery:

Face-to-face teaching and e-learning tool usage

Learning activities and teaching methods:

Face-to-face-teaching (lectures and exercises) 50h, Matlab simulation exercises in groups 30 h, independent work & passed assignment 50 h.

Target group:

Electrical, communications and computer science and engineering students.

Prerequisites and co-requisites:

The required prerequisite is the completion of the following courses prior to enrolling for the course: 031080A Signal Analysis, 031021P Probability and Mathematical Statistics, 031078P Matrix Algebra, 521330A Telecommunication Engineering.

Recommended optional programme components:

521323S Wireless communications I and 031051S Numerical Matrix Analysis are recommended to be taken in parallel.

Recommended or required reading:

Parts from books:
Assessment methods and criteria:
Completing the simulation project tasks, and a mid-term exam during the course. The mid-term exams can be retaken by a final exam later. In the final grade of the course, the weight for the examination is 0.7 and that of project report 0.3.
Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course utilizes a numerical grading scale 1-5. In the numerical scale zero (0) stands for a fail.

Person responsible:
Janne Lehtomäki and Markku Juntti

Working life cooperation:
No

Other information:
-

521395S: Wireless Communications I, 5 cp

Validity: 01.08.2019 -

Form of study: Advanced Studies

Type: Course

Unit: Electrical Engineering DP

Grading: 1 - 5, pass, fail

Teachers: Timo Kokkonen, Jari Iinatti

Opintokohteen kielet (E): English

Leikkaavuudet (E):

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ECTS Credits: 5

Language of instruction: English

Timing:
Fall, period 1

Learning outcomes:
Student
1. can analyze the performance of multilevel digital modulation methods in AWGN channel
2. can explain the effect of fading channel on the performance of the modulation method and can
analyze the performance
3. recognizes and understand suitable diversity methods for fading channel and related combining methods
4. can understand and explain coding methods for wireless channels
5. recognizes different wideband systems
6. understands the cellular system principle

Contents:
Radio channel models, digital modulation and detection methods, carrier and symbol synchronization, performance of digital modulation in AWGN and fading channel, diversity techniques, coding for wireless channel, multicarrier modulation, spread spectrum, cellular systems.

Mode of delivery:
Face-to-face teaching

Learning activities and teaching methods:
Lectures and exercise (total 40 hours) and the compulsory design work with a simulation program (20 h)

Target group:
1st year WCE students and M.Sc. students (i.e., 4th year in ECE degree programme)

Prerequisites and co-requisites:
521330A Telecommunication Engineering

Recommended optional programme components:
-

Recommended or required reading:

Assessment methods and criteria:
The course is passed with minor exams (only during lecture period) or with final exam; and the accepted design work report. In the final grade of the course, the weight for the examination(s) is 0.6 and that for the design work report 0.4.

Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible:
Jari Iinatti / Timo Kokkonen

Working life cooperation:
No

Other information:
-

031025A: Introduction to Optimization, 5 cp

Form of study: Intermediate Studies
Type: Course
Unit: Applied Mathematics and Computational Mathematics
Grading: 1 - 5, pass, fail
Teachers: Ruotsalainen Keijo
Opintokohteen kielet (E): English

ECTS Credits:
5 ECTS credits / 135 hours of work
Language of instruction:
English

Timing:
The course is held in the autumn, during period 1.

Learning outcomes:
After completing the course the student is able to solve optimization convex optimization problems with the basic optimization algorithms. The student is also able to form the necessary and sufficient conditions for the optimality.

Contents:
Linear optimization, Simplex-algorithm, nonlinear optimization, KKT-conditions, duality, conjugate gradient method, penalty and barrier function methods.

Mode of delivery:
Face-to-face teaching

Learning activities and teaching methods:
Lectures 28 h / Group work 14 h / Self-study 93 h.

Target group:
Students in Wireless Communication Engineering

Prerequisites and co-requisites:
The recommended prerequisite is the completion of the courses Calculus I and II, Matrix algebra

Recommended optional programme components:

Recommended or required reading:
P. Ciarlet; Introduction to numerical linear algebra and optimization, M. Bazaraa, H. Sherali, C.M. Shetty; Nonlinear programming

Assessment methods and criteria:
The course can be completed by a final exam.
Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course utilizes a numerical grading scale 0-5. In the numerical scale zero stands for a fail

Person responsible:
Keijo Ruotsalainen

Working life cooperation:

Other information:

521340S: Communications Networks I, 5 cp

Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Mika Ylianttila
Opintokohteen kielet (E): English

ECTS Credits:
5 ECTS cr
Language of instruction:
English

Timing:
Fall, period 2

Learning outcomes:
1. Students understand how the modern communications networks have evolved and how the architecture has changed through the recent paradigm shift towards software-centric communications.
2. Students are able to describe the basic system architecture elements of mobile networks, and understands the significance of emerging technologies such as Network Function Virtualization (NFV), Software Defined Networking (SDN), and core network functionalities such as Evolved Packet Core (EPC).
3. Students can describe the main principles of mobility management, network management and orchestration, and network security, and can apply and solve related engineering problems.
4. Students know the basic properties of routing algorithms, and can use graph theory to solve network routing problems.
5. Students are able to simulate different types of networks in simulation environments and solve basic network programming problems. Upon completing the required coursework, students understand the basic functionalities in TCP/IP protocol stack.

Contents:
Communications architecture in mobile, wireless local area and personal area networks. Introduction to cloud and edge computing, network function virtualization and software defined networking. Basic principles of mobility management, network security, network management and orchestration. The goal is to present the basics of the modern communications architectures, and their technical implementation.

Mode of delivery:
Face-to-face teaching.

Learning activities and teaching methods:
Lectures 30 h and the compulsory design work (15 h). Design work can be done alternatively either as NS-2 simulation or TCP/IP programming exercise. Design work instructions are provided in digital learning environment (Optima / Moodle).

Target group:
1st year M.Sc. and WCE students

Prerequisites and co-requisites:
-

Recommended optional programme components:
The course is an independent entity and does not require additional studies carried out at the same time.

Recommended or required reading:
Software Defined Mobile Networks (SDMN): Beyond LTE Network Architecture, M Liyanage, A Gurtov, M Ylianttila – 2015; A comprehensive Guide to 5G Security, M Liyanage, I Ahmad, A Abro, A Gurtov, M Ylianttila – 2018; In addition, selected supportive online reading materials from recent standards and publications are provided in digital learning environment (Optima / Moodle).

Assessment methods and criteria:
The course is passed with a final examination and the accepted design work report. The final grade is based on examination. Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course unit utilizes a numerical grading scale 1-5.

Person responsible:
Mika Ylianttila
Mika Ylianttila

Working life cooperation:
No

Other information:
-

521324S: Statistical Signal Processing II, 5 cp

Validity: 01.08.2015 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Juntti, Markku Johannes
Opintokohteen kielet (E): English
Leikkaavuudet (E):

521373S Statistical Signal Processing 2  6.0 cp
521373S-01 Statistical Signal Processing 2, exam    0.0 cp
521373S-02 Statistical Signal Processing 2, exercise work  0.0 cp

ECTS Credits:
5

Language of instruction:
English

Timing:
The course is held in the spring semester, during period 3. It is recommended to complete the course at the 1st spring semester of the master studies.

Learning outcomes:
Upon completion the student will
1. understand the key design problems and constraints of the design of typical estimation problems in statistical signal processing.
2. have the skills to apply estimation, detection and other statistical signal processing methods to solve practical problems in communications.
3. can use linear algebra, basics of optimization and statistical signal processing to derive algorithms with statistical models or driven by data.
4. can use numerical analysis to approximate optimal algorithms with iterative solutions including (un)supervised adaptive algorithms.
5. understands the basic requirements for the convergence of an iterative and adaptive algorithm.
6. can model the operation of a transceiver using Matlab and other simulators to assess the performance of transceiver algorithms.

Contents:

Mode of delivery:
Face-to-face teaching and e-learning tool usage

Learning activities and teaching methods:
Face-face-teaching (lectures and exercises) 50h, Matlab simulation exercises in groups 30 h, independent work & passed assignment 50 h.

**Target group:**
Electrical, communications and computer science and engineering students.

**Prerequisites and co-requisites:**
The required prerequisite is the completion of the following courses prior to enrolling for the course: 031080A Signal Analysis, 031021P Probability and Mathematical Statistics, 031078P Matrix Algebra, 521330A Telecommunication Engineering, 521348S Statistical Signal Processing I. The recommended prerequisite is the completion of 521323S Wireless Communications I, 031025A Introduction to Optimization and 031051S Numerical Matrix Analysis.

**Recommended optional programme components:**
521317S Wireless communications II is recommended to be taken in parallel.

**Recommended or required reading:**
Parts from books:

6. Other literature, lecture notes and material.

**Assessment methods and criteria:**
Completing the simulation project tasks, and a mid-term exam during the course. The mid-term exams can be retaken by a final exam later. In the final grade of the course, the weight for the examination is 0.6 and that of project report 0.4.

Read more about [assessment criteria](#) at the University of Oulu webpage.

**Grading:**
The course utilizes a numerical grading scale 1-5. In the numerical scale zero (0) stands for a fail.

**Person responsible:**
Markku Juntti and Janne Lehtomäki

**Working life cooperation:**
No

**Other information:**
-

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**521349S: Wireless Communications II, 5 cp**

**Form of study:** Advanced Studies

**Type:** Course

**Unit:** Electrical Engineering DP

**Grading:** 1 - 5, pass, fail

**Teachers:** Anti-Heikki Tölli

**Opintokohdeet kielet (E):** English

**ECTS Credits:**
5

**Language of instruction:**
Timing:
Spring, periods 3-4

Learning outcomes:
1. The student is familiarised with the channel capacity as the fundamental performance measure of wireless communication links, and can explain the effect of fading channel on the capacity in a single-user single-antenna scenarios.
2. The student understands the basic principles for multiuser communications in fading channels, apprehends the notion of capacity region for multi-access and broadcast channels, and is familiarised with different practical multiple access, random access and scheduling methods.
3. The student is acquainted with core principles of adaptive transmission, which requires accurate channel estimates at the receiver and a reliable information exchange mechanisms between the receiver and transmitter. Practical variable-rate variable-power MQAM modulation techniques for fading channels are introduced.
4. The student understands the principles of transmitter and receiver design in the presence of channel distortion. The student is familiarised with various (adaptive) equalization solutions to combat intersymbol interference.
5. Finally, the student is acquainted with the capacity optimal multi-antenna transmission and reception scheme, as well as, with basic multi-antenna space-time coding schemes in a single-user multiple-input multiple-output (MIMO) communications scenario.

Contents:
Capacity of wireless channels, multiuser communications, adaptive modulation and coding, equalization, point-to-point MIMO communications and space-time coding.

Mode of delivery:
Face-to-face teaching

Learning activities and teaching methods:
Lectures and exercise (total 40 hours) and the compulsory design work with a simulation program (20 h).

Target group:
1st year WCE students and M.Sc. students (i.e., 4th year in ECE degree programme).

Prerequisites and co-requisites:
In addition to courses “521395S Wireless Communications I”, 521348S “Statistical Signal Processing I”, 031025A “Introduction to optimization” and 031051S “Numerical matrix analysis”, a working knowledge in digital communications, random processes, linear algebra, matrix manipulation and detection theory is required.

Recommended optional programme components:
Prior knowledge of 521390S Information Theory and 521392S Convex Optimisation is very useful but not mandatory. The course 521324S Statistical Signal Processing II is recommended to be taken in parallel.

Recommended or required reading:
14.

Assessment methods and criteria:
The course is passed with a final examination and the accepted simulation work report. The final grade is a weighted sum of exam (70%), homework (20%), and work report (10%).

Grading:
The course unit utilizes a numerical grading scale 1-5.
Person responsible:
Antti Tölli

Working life cooperation:
No

Other information:
Course replaces the old course 521317S Wireless Communications II (8cr).

521326S: Radio Engineering 1, 5 cp

Validity: 01.08.2015 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Aarno Pärssinen, Risto Vuohioniemi
Opintokohteen kielet (E): Finnish
Leikkaavuudet (E):

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<tr>
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<td>Radio Engineering</td>
<td>6.0 cp</td>
</tr>
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</table>

ECTS Credits: 5

Language of instruction: English

Timing: Fall, period 2

Learning outcomes:
1. learns key components of radio transceivers used in wireless communications including LTE and 5G.
2. knows different kind of impedance matching methods and can design the impedance matching network using lumped components and microstrip lines. A student can also explain factors, which are limiting the bandwidth of impedance matching networks. Smith chart (admittance/impedance chart).
3. will be able to design a low noise RF amplifier. The amplifier is designed that the noise figure is minimized or the gain is maximized. The impedance matching can also be made for the constant gain.
4. knows single sideband and double sideband noise in mixers. A student will be able to design balanced and double balanced mixer and knows the advantages and the disadvantages of these mixers.
5. will be able to design passive microwave components like a Wilkinson power divider, a directional coupler and hybrids.
6. can explain basic principles of RF-oscillators. A student can design a cross-coupled oscillator and voltage controlled oscillator.
7. knows concept of noise, non-linearity and dynamic range as used in radio frequency communications.
8. can classify power amplifiers and will be able in the basic case design the matching network for a power amplifier.
Contents:
Noise, non-linearity, impedance matching using lumped components, microstrip matching networks, low noise amplifier (LNA) design, active and passive mixers design, Wilkinson power dividers, directional couplers, hybrids, automatic gain control (AGC), cross-coupled oscillator, voltage controlled oscillators, power amplifier design.

Mode of delivery:
Face-to-face teaching

Learning activities and teaching methods:
Lectures 24 h, exercises 16 h and the compulsory RF design work with ADS simulation software (20 h).

Target group:
1st year M.Sc. and WCE-RF students. 2nd year M.Sc. (Telecom.) and WCE-RAN students.

Prerequisites and co-requisites:
Basics of Radio Engineering

Recommended optional programme components:

Recommended or required reading:

Assessment methods and criteria:
The course is passed with a final examination and the accepted simulation work report. In the final grade of the course, the weight for the examination is 0.75 and that for the simulation work 0.25. Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course unit utilizes a numerical grading scale 1-5.

Person responsible:
Risto Vuonthiemi, Aarno Pärssinen.

Working life cooperation:
No

Other information:

Advanced module, obligatory courses, 30 ECTS cr

A453273: Advanced module, Telecommunication Engineering, 10 - 47 cp

Validity: 01.08.2015 -
Form of study: Advanced Module
Type: Study module
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Opintokohteen kielet (E): Finnish

No course descriptions.

Advanced module mandatory courses, choose min. 30 ECTS cr These are alternative:
521322S Telecommunication engineering project or 521300S Electronics design and construction exercise.
521386S: Radio Channels, 5 cp

Validity: 01.08.2011 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Pekka Kyösti, Markus Berg
Opintokohteen kielet (E): English

ECTS Credits:
5 ECTS credits / 130 hours of work
Language of instruction:
English
Timing:
Autumn, period 2.
Learning outcomes:
After completing the course, student
1. will be able to define what the radio channel is and is able to distinguish it into modellable parts.
2. knows different radio wave propagation mechanisms.
3. can apply physical and empirical radio channel models.
4. is able to analyse which are the dominating propagation mechanisms in different environments.
5. will know how to measure the properties of different radio channels.

Contents:

Mode of delivery:
Face-to-face teaching

Learning activities and teaching methods:
Lectures 24 h / Exercises 12 h / compulsory laboratory work 25 h / Self-study 74 h.

Target group:
1st or 2nd year M.Sc. and WCE students

Prerequisites and co-requisites:
The required (or recommended) prerequisite is the completion of the following courses prior to enrolling for the course: Basics of Radio Engineering, Signal Analysis

Recommended optional programme components:
The course is an independent entity and does not require additional studies carried out at the same time.

Recommended or required reading:

Assessment methods and criteria:
The course is passed with a final examination and the accepted laboratory work report. Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible:
Markus Berg / Pekka Kyösti

Working life cooperation:
No

Other information:
-

521328A: Simulations and Tools for Telecommunications, 5 cp

Validity: 01.08.2015 -
Form of study: Intermediate Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Johanna Vartiainen

Opintokohteen kielet (E): Finnish
Leikkaavuudet (E):
- 521369A Simulations and Tools for Telecommunications 3.0 cp
- 521369A-01 Simulations and Tools for Telecommunications, exam 0.0 cp
- 521369A-02 Simulations and Tools for Telecomm. exercise 0.0 cp

ECTS Credits:
5
Language of instruction:
Finnish
Timing:
Fall, period 2
Learning outcomes:
1. A student recognizes problems and limitations related to simulations.
2. She/he can select a suitable simulation method and knows how to validate the model.
3. Student knows how to generate signals, random numbers and noise.
4. She/he knows how to model fading channels.
5. A student knows how to make Monte-Carlo simulations at the baseband level and can estimate confidence level of simulation results.
6. She/he can explain principles of network level simulations.
7. A student knows basics of one or two fundamental simulation programs
Contents:
Simulation methods, modelling communication systems with simulations, confidence limits of simulation, noise generation and modelling of fading channel. A simple baseband simulation example. Basics of MATLAB and OPNET simulation software (these could vary depending on needs /availability).

Mode of delivery:
Face-to-face teaching

Learning activities and teaching methods:
Lectures 24 h (including program introductions), and the compulsory assignment with a simulation program (40 h).

Target group:
3\textsuperscript{rd} year bachelor's degree students and M.Sc. students

Prerequisites and co-requisites:
Telecommunication Engineering

Recommended optional programme components:
The course is an independent entity and does not require additional studies carried out at the same time.

Recommended or required reading:

Assessment methods and criteria:
The course is passed with a final examination and the accepted simulation work report. The final grade is based on exam.
Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course unit utilizes a numerical grading scale 1-5.

Person responsible:
Johanna Vartiainen

Working life cooperation:
No

Other information:
-

521327S: Radio Engineering II, 6 cp

Validity: 01.08.2015 -

Form of study: Advanced Studies

Type: Course

Unit: Electrical Engineering DP

Grading: 1 - 5, pass, fail

Teachers: Risto Vuohtoniemi, Aarno Pärssinen

Opintokohteen kielet (E): English

Leikkaavuudet (E):
521375S  Design of Tranceivers  5.0 cp
521375S-01  Design of tranceivers, partial credit  0.0 cp
**ECTS Credits:**
6 ECTS cr

**Language of instruction:**
English

**Timing:**
Spring, period 3

**Learning outcomes:**
1. understands radio system and RF design for modern wireless equipment like cellular phones.
2. recognizes the blocks of a transceiver and can explain the operating principle of a transceiver.
3. can classify different architectures used in a single and a multi-antenna transceiver and understand the basis for them.
4. will be able to define parameters used in the transceiver system level design and can design a transceiver at the system level so that the requirements for the system are fulfilled.
5. knows nonlinear distortion and can design the automatic gain control in the system level.
6. will be able to explain factors, which are important for the selection of D/A- and A/D-converters and can derive various methods to create the in phase and the quadrature components of a received signal.
7. understands the principles of frequency synthesis in a transceiver.
8. understands principles of key implementation technologies of radio transceivers and relation to electronics.

**Contents:**
Designing a transceiver at the system level, transceiver architectures, performance characteristics of transceivers, nonlinearities, factors which limit the performance of a transceiver, placement of the A/D-converter in a receiver, frequency synthesis, design and implementation examples.

**Mode of delivery:**
Face-to-face teaching

**Learning activities and teaching methods:**
Lectures 32 h and the compulsory design exercise with ADS simulation software (54 h).

**Target group:**
1st year M.Sc. and WCE-RF students

**Prerequisites and co-requisites:**
Radio Engineering I

**Recommended optional programme components:**
-

**Recommended or required reading:**

**Assessment methods and criteria:**
The course is passed with a final examination and the accepted simulation work report. In the final grade of the course, the weight for the examination is 0.75 and that for the simulation work 0.25. Read more about assessment criteria at the University of Oulu webpage.

**Grading:**
The course unit utilizes a numerical grading scale 1-5.
Person responsible:
Risto Vuohtoniemi, Aarno Pärssinen.

Working life cooperation:
No

Other information:
-

521377S: Communications Networks II, 7 cp

Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Mika Ylianttila
Opintokohteen kielet (E): English

ECTS Credits:
7 ECTS cr

Language of instruction:
English

Timing:
Spring, periods 3-4

Learning outcomes:
1. Upon completing the required coursework, the students understand basic principles of programmable networking. The students understand the challenges in existing architectures and how Software Defined Networking (SDN) can solve those challenges.
2. Students understand the idea of SDN network control and data planes, and what it means in practice. The students learn how the network control-data plane separation is possible with SDN. The students have knowledge of how different control plane architectures can be developed or used for different networked environments.
3. Students understand the novel features in the 5G architecture, such as Multi-Access Edge Computing (MEC) and Network Function Virtualization (NFV) and the benefits of MEC and NFV for mobile networks. Students understand the importance of edge computing and virtualization techniques in achieving the low-latency and reliability requirements of 5G standard. Students know the planned use cases of multi-access edge computing in 5G systems and can describe some of the system architecture components.
4. Students understand the significance of network security, network load-balancing and network slicing in modern and emerging communications networks and how they need to be taken into consideration when using SDN and NFV.
5. Students understand the dynamics of simple programmable networks, the importance of queuing systems in the current model of programmable networks such as OpenFlow-based SDNs. The student is also able to design a queuing system for SDN-based network control plane to provide services in a balanced way to the underlying data plane the control plane is responsible for.
6. Students understand the basic principles of queueing theory, such as Birth and Death Process, the $M/M/1$, $M/M/c$, $M/M/c/K$ and queueing networks models. Students understand concept of Markov model and its application in communication network analysis. Students can apply queueing theory to model SDN or virtualized networks.
7. Students learn skills to design and implement simple SDNs and analyze performance in network emulation and simulation environments.

Contents:
Introduction to the concepts of Software Defined Networking (SDN): the OpenFlow based SDN architecture, SDN control plane and data plane (OpenFlow switches), Software Defined Monitoring, SDN and Network Function Virtualization (NFV) integration in cellular systems. Introduction to Multi-Access Edge computing (MEC), and the use cases of MEC in 5G, and MEC-IoT integration. Introduction to queueing theory and queueing systems and application of queueing theory to model software defined mobile network or virtualized networks (Jackson network). Furthermore, the course discusses the significance of network security, network load-balancing and network slicing in modern and emerging communications networks. Course provides hands-on experience on virtual networks using SDN with Mininet network emulator.

**Mode of delivery:**
Face-to-face teaching

**Learning activities and teaching methods:**
Lectures 30 h, exercises 15 h and the compulsory design work with a simulation program (30 h). Description of Mininet exercises and Simulink simulation design work are provided in digital learning environment (Optima / Moodle).

**Target group:**
1st year M.Sc. and WCE students.

**Prerequisites and co-requisites:**
Communications Networks I

**Recommended optional programme components:**
The course is an independent entity and does not require additional studies carried out at the same time.

**Recommended or required reading:**

**Assessment methods and criteria:**
The course is passed with a final examination and the accepted emulation/simulation work report. The final grade is based on examination.
Read more about [assessment criteria](#) at the University of Oulu webpage.

**Grading:**
The course unit utilizes a numerical grading scale 1-5.

**Person responsible:**
Mika Ylianttila

**Working life cooperation:**
No

**Other information:**
- 

**521388S: Antennas, 5 cp**

**Validity:** 01.08.2015 -

**Form of study:** Advanced Studies

**Type:** Course

**Unit:** Electrical Engineering DP

**Grading:** 1-5, pass, fail

**Teachers:** Markus Berg

**Opintokohteen kielet (E):** English
Leikkaavuudet (E):

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<tr>
<td>521380S-02</td>
<td>Antennas, partial credit</td>
<td>0.0 cp</td>
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ECTS Credits:
5 ECTS credits / 135 hours of work

Language of instruction:
English

Timing:
Spring, period 4

Learning outcomes:
After completing the course, student
1. knows antenna terminology and understands the role of antennas as a part of different radio systems.
2. is familiar with the theories explaining the electromagnetic radiation of usual antenna types and antenna arrays.
3. will be able to design wire antennas, micro strip antennas and antenna arrays for different radio systems.
4. will be able to design and analyze various antenna types and arrays using 3D electromagnetic simulation software.

Contents:

Mode of delivery:
Face-to-face teaching

Learning activities and teaching methods:
Lectures and exercises 40 h / Compulsory antenna design work with an electromagnetic simulation 25 h / Self-study 70 h

Target group:
1st or 2nd year M.Sc. and WCE students

Prerequisites and co-requisites:
The required prerequisite is the completion of the following courses prior to enrolling for the course: Basics of Radio Engineering 521384A

Recommended optional programme components:
The course is an independent entity and does not require additional studies carried out at the same time.

Recommended or required reading:

Assessment methods and criteria:
The course is passed with a final examination and the accepted design work report. In the final grade of the course, the weight for the examination is 0.5 and that for the design work 0.5. Read more about assessment criteria at the University of Oulu webpage.
The course utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible:
Markus Berg

Working life cooperation:
No

Other information:
-

521279S: Signal Processing Systems, 5 cp

Validity: 01.08.2012 -
Form of study: Advanced Studies
Type: Course
Unit: Computer Science and Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Pekka Sangi
Opintokohteen kielet (E): Finnish

ECTS Credits:
5 ECTS cr
Language of instruction:
English
Timing:
Autumn, period 2
Learning outcomes:
1. Student can explain the challenges of signal processing hardware, software, and design methodologies.

2. Student is able to transform a digital filter designed with floating point arithmetic into a fixed point precision implementation, optimizing the word lengths to achieve the performance specifications.

3. Student is able to explain the most important algorithm implementation structures and can identify their usage contexts.

4. Student has rudimentary practical skills in modeling, designing, and judging finite word length signal processing algorithms with Matlab and Simulink software tools.

Contents:
Binary and floating point arithmetic, DSP programming models and co-design, digital signal processors, algorithms and implementations, including CORDIC, transforms (FFT and DCT), multirate signal processing, polyphase filters, filter banks, adaptive algorithms and applications. The software environments of the course are Matlab with the Fixed Point Toolbox extension and Simulink with the DSP Blockset extension.

Mode of delivery:
Lectures, independent work, group work.

Learning activities and teaching methods:
The course consists of lectures (30 h) and design exercises (6-12 h), the rest as independent work (33h).
**Target group:**
Computer Science and Engineering students: This is an advanced-level course intended for masters-level students, especially to those that are specializing into signal processing. + Other Students of the University of Oulu.

**Prerequisites and co-requisites:**
521337A Digital Filters, 521267A Computer Engineering or 521286A Computer Systems, 8 ECTS cr or 521287A Introduction to Computer Systems, 5 ECTS cr

**Recommended optional programme components:**
The course is an independent entity and does not require additional studies carried out at the same time.

**Recommended or required reading:**
Lecture notes and exercise materials. Material is in English.

**Assessment methods and criteria:**
Grading is based on the evaluation of the design exercises, which are done during the course, and exams, which are arranged during the lectures.
Read more about assessment criteria at the University of Oulu webpage.

**Grading:**
The course unit utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

**Person responsible:**
Pekka Sangi

**Working life cooperation:**
None.

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**521322S: Telecommunication Engineering Project, 5 cp**

**Validity:** 01.08.2015 -

**Form of study:** Advanced Studies

**Type:** Course

**Unit:** Electrical Engineering DP

**Grading:** 1 - 5, pass, fail

**Teachers:** Markus Berg, Saarnisaari, Harri Tapani

**Opintokohteen kielet (E):** Finnish

**Leikkaavuudet (E):**
- 521387S Telecommunication Engineering Project 4.0 cp

**ECTS Credits:**
5 ECTS credits / 135 hours of work

**Language of instruction:**
English/Finnish

**Timing:**
Fall or Spring, periods 1-4

**Learning outcomes:**
After completing the course student can
1. depending on the work subject, either solve, design, construct, measure, simulate, test or analyze limited telecommunication and radio system and sub-system problems.
2. apply the technical knowledge acquired from advanced sources into practical engineering tasks.
3. document technical and scientific results.
Contents:
Varies depending on the topic.

Mode of delivery:
Independent work.
If you would like to take the course, you can contact the course person responsible.

Learning activities and teaching methods:
The design exercise is done in a group of one or two students depending of work’s difficulty. The design exercise can be simulation or implementation work. The work can be defined by the Department of Communications Engineering or by industry. In the later case a proposal must be submitted to the teacher before beginning of the work. Also, student must meet the schedule and deadlines given by a supervisor before starting the work. In preparing the work report document the writing instructions of DCE department's diploma thesis must be followed.

Target group:
1st or 2nd year M.Sc. and WCE students

Prerequisites and co-requisites:
Depending on the subject: advanced courses dealing with telecommunication systems, digital communications, digital signal processing or/and radio engineering.

Recommended optional programme components:
The course is an independent entity and does not require additional studies carried out at the same time.

Recommended or required reading:
Varies depending on the topic.

Assessment methods and criteria:
Written work report.
Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible:
Markus Berg / Harri Saarnisaari

Working life cooperation:
No

Other information:

521300S: Electronics Design and Construction Exercise, 6 cp

Validity: 01.08.2015 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Kari Määttä

Opintokohteen kielet (E): Finnish
Leikkaavuudet (E):
521441S Electronics Design and Construction Exercise 6.5 cp

ECTS Credits:
6
Language of instruction:
Finnish, English

Timing:
Periods 1-4

Learning outcomes:
1 is able to carry out all the stages needed to develop an electronic circuit or device starting from independent creation and design work to realization, testing and technical documentation.
2 is able to use independently without any help professional methods, software packages, measurement devices and tools.
3 Objective: To familiarize the student with independent electrical circuit and system design and with the methods and tools used in the design process. The course prepares the student for the diploma work in the area of circuits and system design.

Contents:
Design and construction of an electronic device or a part of a device according to the given specification. The task can be part of an industrial research or a product design project or part of the research project going on in Electronics or other laboratory. The subject of the work can be own suggestion of the student or a pre-selected course subject, which enables comprehensive training of skills needed for the design of a modern electronic device.

Mode of delivery:
Independent work.

Learning activities and teaching methods:
Independent design and construction work 180h

Target group:
Primarily in electrical engineering students. Other University of Oulu students can complete the course

Prerequisites and co-requisites:
Student must have passed following courses: Analogue Electronics I-II, Digital Techniques I-II, Electronic System Design and Filter Theory.

Recommended optional programme components:
The course is an independent entity and does not require other studies carried out at the same time.

Recommended or required reading:
Not defined

Assessment methods and criteria:
The task can be carried out by a student or by a team of two students. The grade will be decided on the basis of the statement of the instructor, realization of the device and the report provided by the student.
Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course unit utilizes a numerical grading scale 0 - 5. In the numerical scale 0 stands for a fail.

Person responsible:
Kari Määttä

Working life cooperation:
No

521318S: Modern Topics in Telecommunications and Radio Engineering, 3 - 7 cp

Form of study: Advanced Studies
Type: Course
**Unit:** Electrical Engineering DP  
**Grading:** 1 - 5, pass, fail  
**Teachers:** Matti Latva-aho, Jari Iinatti  
**Opintokohteen kielet (E):** English  
**Voidaan suorittaa useasti (E):** Yes  

**ECTS Credits:**  
3-7  

**Language of instruction:**  
English  

**Timing:**  
Fall & Spring, periods 1-4  

**Learning outcomes:**  
After completing the course the student understand and is able to analyze basic principles of the topic which has been presented in the course. The final outcomes will be defined based on the contents.  
Objective: Depending on each year's topic, the course gives either an overview or deepens knowledge of actual topics and applications on radio techniques and telecommunications. The course comprises varying topical subjects, applications, research areas. Depending on the subject, the course may comprise a seminar of essays that practices a student for spontaneously acquiring information, improves readiness for making a master's thesis and readiness for performing in front of an audience.  

**Contents:**  
Varies yearly based on actual topics in telecommunications and radio engineering.  

**Mode of delivery:**  
Face-to-face teaching  

**Learning activities and teaching methods:**  
Lectures and/or exercises and/or design exercise and/or seminars depending on the topic of the year. The start and implementation of the course will be informed separately. The course can be given several times with different contents during the academic year and it can be included into the degree several times.  

**Target group:**  
1st and 2nd year M.Sc. and WCE students.  

**Prerequisites and co-requisites:**  
Will be defined based on the contents.  

**Recommended optional programme components:**  
-  

**Recommended or required reading:**  
Will be defined in the beginning of the course.  

**Assessment methods and criteria:**  
Depends on the working methods.  

**Grading:**  
The course unit utilizes a numerical grading scale 1-5.  
Read more about assessment criteria at the University of Oulu webpage.  

**Person responsible:**  
Matti Latva-aho, Jari Iinatti  

**Working life cooperation:**
521389S: Wireless Body Area Networks, 5 cp

Validity: 01.08.2019 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Matti Hämäläinen
Opintokohteen kielet (E): English

ECTS Credits:
5 ECTS cr

Language of instruction:
English

Timing:
Spring, period 3-4, will be lectured first time in 2020

Learning outcomes:
Upon completing of the course, the student will be able to
1. distinguish the basic short range communications technologies used in the wireless body area network context,
2. understand the most relevant standards,
3. differentiate and compare the key points behind these standardized technologies and what are their advantages and disadvantages.
4. understand the major characteristics and applications utilizing WBAN and
5. understand the impact of wireless channels on the WBAN system and how channel affects to the WBAN system performance.

Contents:
Introduction, existing short range radio technologies, application, WBAN architecture, sensors & actuators & wearables, WBAN protocols, signal propagation within a human, WBAN antennas, WBAN transceivers, conclusion.

Mode of delivery:
Face-to-face teaching, compulsory seminar presentation

Learning activities and teaching methods:
Lectures 28 h + compulsory seminar presentation

Target group:
1st year WCE students and M.Sc. students (i.e., 4th year in EE degree programme). Special target group is students focusing on medical information and communications technologies.

Prerequisites and co-requisites:
-

Recommended optional programme components:
This course is an independent entity.

Recommended or required reading:
There is no recommended textbook for this course. Course material consists of lecture notes and selected publications.
Assessment methods and criteria:
Passing the course requires an accepted final exam and given seminar presentation.

Grading:
The course unit utilizes a numerical grading scale 1-5.

Person responsible:
Matti Hämäläinen

Working life cooperation:
No

Other information:
Course will be given every second year in even years. Will be held next time in Spring 2020.

521325S: Communication Signal Processing, 5 cp

Validity: 01.08.2015 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Juntti, Markku Johannes

Opintokohteen kielet (E): English

Leikkaavuudet (E):

521360S   Synchronisation for Digital Receivers   4.0 cp
521360S-01 Exam, Communication Signal Processing II   0.0 cp
521360S-02 Synchronisation for Digital Receivers, exercise work   0.0 cp

ECTS Credits:
5 ECTS cr / 130 hours of work

Language of instruction:
English

Timing:
The course is held bi-annually in the spring semester, during period 4. It is recommended to complete the course at the 1st or 2nd spring semester of the master studies.

Learning outcomes:
Upon completion the student

1. knows the functional structure of communications transceiver and understands the requirements for various wireless systems for the transceiver.
2. knows the architectural and functional design of (all-)digital transceiver with synchronization, channel estimation, encoding/decoding, multiantenna processing and connection establishment.
3. understands the requirements of the current wireless communications standards and related multiplexing and multiple access on transceiver design.
4. can derive digital domain algorithms for separate functionalities and match them to operate together via agreed interfaces.
5. can model the operation of the algorithms and the whole transceiver using Matlab and C other to assess their performance by computer simulations.

Contents:
Wireless transceiver functional split, digital parts and architecture, multirate filtering and filter banks, transceiver digital front-end architecture and design, synchronization and channel estimation, equalization and soft detection, algorithm-architecture co-simulation, multiantenna transceivers.

**Mode of delivery:**
Face-to-face teaching and e-learning tool usage.

**Learning activities and teaching methods:**
Face-face-teaching (lectures, exercises and seminar presentations) 30 h, Simulation and design exercises and presentation preparation in groups 80 h, independent work & passed assignment 20 h.

**Target group:**
Electrical, communications and computer science and engineering students.

**Prerequisites and co-requisites:**
The required prerequisite is the completion of the following courses prior to enrolling for the course: 521348S Statistical signal processing I, 521324S Statistical Signal Processing II, 521323S Wireless communications I, 521317S Wireless communications II.

**Recommended optional programme components:**
-

**Recommended or required reading:**
Parts from books:
5. Other literature, lecture notes and material.

**Assessment methods and criteria:**
Completing the design and simulation projects, giving a seminar presentation on those, and a final exam. In the final grade of the course, the weight for the examination is 0.5 and that of project report 0.5.
Read more about assessment criteria at the University of Oulu webpage.

**Grading:**
The course utilizes a numerical grading scale 1-5. In the numerical scale zero (0) stands for a fail.

**Person responsible:**
Markku Juntti

**Working life cooperation:**
The project focuses on timely design problems in wireless industry. Industrial visiting lectures are organized. The project can be done as true industrial design project.

**Other information:**
Course will be given every second year in odd years. Will be held next time in the spring of 2021.

**521390S: Information Theory, 5 cp**

**Validity:** 01.08.2019 -

**Form of study:** Advanced Studies

**Type:** Course

**Unit:** Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Hirley Alves, Markus Leinonen
Opintokohteen kielet (E): English

ECTS Credits:
5

Language of instruction:
English

Timing:
Fall, period 1, will be lectured first time in 2020

Learning outcomes:
Upon completing the required coursework, the student is able to use the basic methodology of information theory to calculate the capacity bounds of communication and data compression systems. He can estimate the feasibility of given design tasks before the execution of the detailed design. What is more, she can independently search for information and knowledge related to communication engineering, system design and signal processing.

Contents:
Entropy, mutual information, data compression, basics of source coding, discrete channels and their capacity, the Gaussian channel and its capacity, rate distortion theory, quantization methods, introduction to network information theory, introduction to network coding, modern topics in information theory, compressed sensing, and information theory tools for machine learning.

Mode of delivery:
Face-to-face teaching

Learning activities and teaching methods:
Lectures and exercises 50 h, homework, seminar and compulsory lab assignments 30 h, independent work 50 h.

Target group:
2nd year M.Sc. electrical and communications engineering, WCE as well as computer science and engineering students

Prerequisites and co-requisites:
Signal Analysis, Telecommunication Engineering, Probability and Mathematical Statistics.

Recommended optional programme components:
Wireless Communications I and II, Statistical Signal Processing I and II.

Recommended or required reading:
Parts from books
Lecture notes and other literature.

Assessment methods and criteria:
The course is passed with two mid-term exams or with a final exam, and the accepted lab exercise report. The final grade is a weighted sum of exam (70%), homework and seminars (20%), and lab exercise (10%).

Grading:
The course unit utilizes a numerical grading scale 1-5.

Person responsible:
Hirley Alves/Markus Leinonen

Working life cooperation:
Objective: To learn the information theory as a discipline and its most important applications in information technology in general and in communications engineering.

521391S: Channel Coding and Modulation, 5 cp

Validity: 01.08.2019 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Rajatheva Rajatheva
Opintokohteen kielet (E): English

ECTS Credits: 5
Language of instruction: English
Timing: Fall, period 1, next time in year 2021
Learning outcomes:
1. Student is fully conversant with commonly used error control coding techniques – block, convolutional, TCM, Lattice, Turbo, LDPC, Polar: code construction and decoding algorithms.
2. Student is able to evaluate the performance of a given code by analytical or computational-simulation methods.
3. Student is able to read and understand peer reviewed publications in Coding.

Contents:
Introduction: Groups, Rings, Fields, Construction of higher level Galois Fields, Factoring Linear, Cyclic and Convolutional codes – Viterbi and Sequential decoding Golay code, Reed Muller, Non binary BCH, Reed Solomon (RS) Codes and Decoding with Berlekamp Massey (BM) Algorithm Lattice Codes: Introduction to Coded Modulation, Ungerboeck and Forney Constructions, Packing, Covering, Voronoi Constellations Turbo Codes: BCJR Algorithm, Extrinsic Information, EXIT Chart Soft-input Soft-output (SISO) Decoding, Serial and Parallel concatenated codes, Application in 3G and 4G systems LDPC Codes: Low density parity check matrices, encoding, Decoding in a graph, QC-LDPC, Application in WiFi and enhanced mobile broadband (eMBB) in 5G Polar Codes: Successive Cancellation decoding, List decoding, Short frame codes, Control channel in 5G Applications and Developments: Satisfying latency and reliability in 5G through coding, Application of coding in Distributed Computing, Storage, Application of learning methods in coding

Mode of delivery:
Face-to-face teaching

Learning activities and teaching methods:
Lectures and exercises 50 h and compulsory homework and lab assignments 35 h.

Target group:
2nd year M.Sc. and WCE students

Prerequisites and co-requisites:

No
Probability and Statistics

**Recommended optional programme components:**

- 

**Recommended or required reading:**

Parts from books
Error Control Codes, Shu Lin and Costello, Pearson, 2005, 2nd Edition
Lecture notes and other literature.

**Assessment methods and criteria:**

The course is passed with two mid-term exams or with final exam.
The final grade is a weighted sum of exams (50%), homeworks (45%), and lab exercise (5%).

**Grading:**
The course unit utilizes a numerical grading scale 1-5.

**Person responsible:**
Nandana Rajatheva

**Working life cooperation:**
No

**Other information:**
Objective: Comprehensive course on coding techniques, including non binary constructions based on higher level Galois Fields, codes based on graphs and new applications The course will start on Galois field constructions based on integer rings and continue with detailed Berlekamp-Massey Algorithm, Lattice Codes based on David Forney papers, Turbo, LDPC and Polar Codes as applied in 4G and 5G.

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**521392S: Convex Optimization, 7 cp**

**Validity:** 01.08.2019 -

**Form of study:** Advanced Studies

**Type:** Course

**Unit:** Electrical Engineering DP

**Grading:** 1 - 5, pass, fail

**Teachers:** Antti-Heikki Tölli, Italo Atzeni, Satya Joshi

**Opintokohteen kielet (E):** Finnish

**ECTS Credits:**
7 ECTS credits

**Language of instruction:**
English

**Timing:**
Autumn (periods 1 and 2)

**Learning outcomes:**
- The course introduces frameworks and systematic guidelines to handle mathematical optimization problems.
- The students will understand the basic tools and techniques to recognize, formulate, and reformulate various engineering problems as convex optimization problems.
The students will understand the necessary and sufficient conditions for optimality; familiarize with dual problems; investigate the sensitivity of the optimal value with respect to perturbations.

The students will be able to solve linear, quadratic, geometric, and semidefinite programming problems by using interior point methods; apply descent methods and Newton's methods; solve KKT systems.

The students will familiarize with high-level optimization solvers and will be able to develop specific solvers/algorithms for their research problems.

The students will be able to recognize the role of convex optimization in various engineering applications including signal processing, wireless communications, networking, and machine learning.

Contents:

1. Fundamental of convex analysis: convex sets, convex functions.
   a. Convex sets: affine and convex sets, operations that preserve convexity, separating and supporting hyperplanes, dual cones and generalized inequalities.
   b. Convex functions: convex, quasi-convex, log-convex, and conjugate functions, first-order condition, epigraph, sublevel sets, operations that preserve convexity, convexity with respect to generalized inequalities.

2. Optimization problems and transformations, local and global optima, optimality criterion, linear programming, quadratic programming, geometric programming, second-order cone programming, semidefinite programming, generalized inequality constraints, vector optimization.

3. Duality theory, geometric/saddle-point interpretation, optimality conditions, perturbation and sensitive analysis.

4. Applications to signal processing, wireless communications, and machine learning.


6. Practical sessions using CVX.

Mode of delivery:
Face-to-face teaching

Learning activities and teaching methods:
Self-lectures, face-to-face lectures, exercises, and final project.

Target group:
Primarily communications engineering students. Other students from the University of Oulu can complete the course.

Prerequisites and co-requisites:
In addition to courses 031025A “Introduction to optimization” and 031051S “Numerical matrix analysis”, a working knowledge in digital communications, random processes, linear algebra, matrix manipulation and detection theory is required.

Recommended optional programme components:

Recommended or required reading:

- IEEE Magazine/Journals related to mathematical optimizations and applications.
- The course reader, homework with solutions, and other material by Prof. Boyd are available on his web page: http://web.stanford.edu/class/ee364a/
- The video lectures of Prof. Boyd are available on YouTube: https://www.youtube.com/watch?v=McLq1hEq3UY&list=PL3940DD956CDF0622

Assessment methods and criteria:

- 521392S: written exams (50%), exercises (25%), project work (25%).
- 520010J: written exams (40%), exercises (20%), project work (40%).
The written exams include mid-term and final exam.

**Grading:**
The course unit utilizes a numerical grading scale (1-5).

**Person responsible:**
Antti Tölli, Satya Joshi, Italo Atzeni

**Working life cooperation:**
No

**Other information:**
For the academic year 2019/2020, the course 521392S (7 ECTS credits) will be held under the course 522010J.
The course content, self-lectures, face-to-face lectures, exercises, and written exams will be the same for 520010J (10 ECTS credits) and 521392S (7 ECTS credits). A larger and more involved project work will be required for 520010J with respect to 521392S.

- The first period will focus on the basic theoretical aspects and will consist of self-lectures and face-to-face lectures (one per week). Before each face-to-face lecture, the students will be required to watch a video lecture by Prof. Boyd, aided by the corresponding material. The first part of each face-to-face lecture will be devoted to recap and questions/clarifications from the self-lectures, while the second part will focus on practical examples and exercises.
- The second period will focus mostly on relevant applications and will consists of face-to-face lectures (two per week).

**521393S: Statistical Communication Theory, 7 cp**

**Validity:** 01.08.2019 -

**Form of study:** Advanced Studies

**Type:** Course

**Unit:** Electrical Engineering DP

**Grading:** 1 - 5, pass, fail

**Teachers:** Rajatheva Rajatheva

**Opintokohteen kielet (E):** English

**ECTS Credits:**
7

**Language of instruction:**
English

**Timing:**
Fall, period 1-2, next time in 2020

**Learning outcomes:**
1. Student is conversant with commonly used estimation and detection techniques: receiver design and algorithms.
2. Student is able to evaluate the performance of a wireless receiver by analytical or simulation methods.
3. Student is able to read and understand peer reviewed publications in relevant topics.
4. Student is familiar with the novel applications in physical layer and new directions including 5G and beyond
5. Student can observe and explain the performance of these technologies with variable system and channel parameters through the course laboratory exercise – Vienna simulator.

**Contents:**
derivations, Waveforms for mm-wave and higher frequencies, Application of learning methods in Physical layer

**Mode of delivery:**
Face-to-face teaching

**Learning activities and teaching methods:**
Lectures and exercises 70 h and compulsory home assignments and lab 50 h

**Target group:**
2nd year M.Sc. and WCE students

**Prerequisites and co-requisites:**
Signals and Systems, Probability, Random Variables and Processes, Linear Algebra

**Recommended optional programme components:**
Wireless Communications I, Statistical Signal Processing I

**Recommended or required reading:**
Parts from books

**Assessment methods and criteria:**
The course is passed two mid-term exams or with final exam. The final grade is a weighted sum of exam (50%), home assignments (45%), and lab exercise (5%).

**Grading:**
The course unit utilizes a numerical grading scale 1-5.

**Person responsible:**
Nandana Rajatheva

**Working life cooperation:**
No

**Other information:**
Objective is to develop a theoretical understanding of statistical communication theory.

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**521394S: Multiantenna Communications, 5 cp**

**Form of study:** Advanced Studies

**Type:** Course

**Unit:** Electrical Engineering DP

**Grading:** 1 - 5, pass, fail

**Teachers:** Antti-Heikki Tölli

**Opintokohteen kielet (E):** English

**ECTS Credits:**
5

**Language of instruction:**
English

**Timing:**
Fall, period 1
Learning outcomes:

1. Upon completing the coursework, the student will have a deep understanding of the fundamental multiantenna transmission and reception concepts used in broadband wireless systems.
2. The student understands and can derive the channel capacity for various multiple-input multiple-output (MIMO) communication scenarios, can explain the effect of having the channel state information at the transmitter, and is acquainted with physical modelling of MIMO channels.
3. The student have knowledge of generalized MIMO transmitter and receiver structures for scenarios with and without channel state information. Both linear and non-linear transceiver structures are covered. The Massive MIMO foundations are reviewed including a brief introduction to the its analysis via random matrix theory.
4. After learning the basics in a single-user MIMO communications, the student is acquainted with the basic principles for multiuser multiantenna communications in fading channels and can derive the capacity region for MIMO multi-access and broadcast channels.
5. After the course, the student has also gained understanding on the applicability of multiuser MIMO communication and interference management schemes in realistic multi-cell scenarios, and how these technologies are deployed in current and future wireless systems and standards. In addition, hybrid beamforming and low precision quantization schemes are covered especially intended for mmWave and TeraHz communication scenarios.

Contents:

Point-to-point MIMO communications, multiuser multiple antenna communications in uplink and downlink, opportunistic communications, massive MIMO, beamforming for mmWave, scheduling and interference management, coordinated multi-cell transmission.

Mode of delivery:

Face-to-face teaching

Learning activities and teaching methods:

Lectures and exercise (total 40 hours) and the compulsory design work with a simulation program (20 h).

Target group:

Target group 2nd year WCE students and M.Sc. students (i.e., 5th year in ECE degree programme).

Prerequisites and co-requisites:

"521317S Wireless Communications II", 521348S “Statistical Signal Processing I”, 031025A “Introduction to optimization” and 031051S “Numerical matrix analysis”, a working knowledge in digital communications, random processes, linear algebra, matrix manipulation and detection theory is required.

Recommended optional programme components:

Recommended optional programme components Prior knowledge of 521390S Information Theory, 521324S Statistical Signal Processing II and 521392S Convex Optimisation is very useful but not mandatory.

Recommended or required reading:

D. N. C. Tse and P. Viswanath, Fundamentals of Wireless Communication. Cambridge University Press, 2005, Chapters 7-10, as well as, a few recent journal publications related to multiuser MIMO, massive MIMO, cooperative transmission reception, interference management and mmWave beamforming.


Assessment methods and criteria:

The course is passed with a final examination and the accepted simulation work report. The final grade is a weighted sum of exam (70%), homeworks (20%), and work report (10%).

Grading:

The course unit utilizes a numerical grading scale 1-5.
Person responsible: Antti Tölli
Working life cooperation: No
Other information: Course will be given every second year in odd years. Will be held next time in Fall 2021.

Optional Studies

A453295: Advanced Module, Telecommunication Engineering (optional studies), 11 - 37 cp

Validity: 01.08.2015 -
Form of study: Advanced Module
Type: Study module
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Opintokohteen kielet (E): Finnish

No course descriptions.

Optional studies, until the degree is full (120 ECTS cr)

555285A: Project management, 5 cp

Validity: 01.01.2014 -
Form of study: Basic Studies
Type: Course
Unit: Field of Industrial Engineering and Management
Grading: 1 - 5, pass, fail
Teachers: Kirsi Aaltonen
Opintokohteen kielet (E): Finnish
Leikkaavuudet (E):

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ECTS Credits:
5 ECTS credits.

Language of instruction:
Finnish. English material may also be used.

Timing:
Period 2.

Learning outcomes:
Upon completion of the course, the student will be able to:
• describe explain the essential concepts and methods related to project management
• apply project management methods to create a schedule for a project and calculate critical path
• understand essential concepts related to project cost management and able to apply earned value method and three point estimate to manage project costs
• recognises the essential tasks of project risk management

Contents:
Defining project management, project goals and objectives, project phases and project life-cycle management, project planning, organising and scope management, schedule management, cost management, earned value calculation and project risk management, project stakeholder management, project communications management, the role of project manager, new modes of project delivery

Mode of delivery:
The tuition will be implemented as web-based teaching.

Learning activities and teaching methods:
Web-based lectures 16h, self-study 118h

Target group:
Industrial Engineering and Management students and other students taking Industrial Engineering and Management as minor.

Prerequisites and co-requisites:
No prerequisites exist.

Recommended optional programme components:
This course is part of the 25 ECTS module of Industrial engineering and management that also includes 555225P Basics of industrial engineering and management, 555242A Product development, 555264P Managing well-being and quality of working life, and 555286A Process and quality management.

Recommended or required reading:
Lecture material, exercise book, Artto, Martinsuo & Kujala 2006. Projektiliiketoiminta. WSOY

Assessment methods and criteria:
Assignments, exercise book and exam. The course grading is based on the exam. Well completed assignments and exercise book may raise grading.

Grading:
The course utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible:
Assistant professor Kirsi Aaltonen

Working life cooperation:
The course includes guest lectures from industry

Other information:
Substitutes courses 555280P Basic Course of Project Management + 555282A Project Management.

555391S: Advanced Course in Project Management, 5 cp

Validity: 01.08.2015 -

Form of study: Advanced Studies

Type: Course

Unit: Field of Industrial Engineering and Management

Grading: 1 - 5, pass, fail

Teachers: Kirsi Aaltonen

Opintokohteen kielet (E): English

Leikkaavuudet (E):

555381S Project Leadership 5.0 cp

ECTS Credits:
5 ECTS credits.

Language of instruction:
English.

Timing:

Periods 1-2.

Learning outcomes:
Upon completion of the course, the student will be able to:
- explain and describe the most important project management areas and tools
- identify and evaluate the most applicable managerial approaches for different types of projects
- identify development needs and opportunities in project-based organisations
- to develop project management processes in an organisation

Contents:
different type of projects and industry specific approaches to project management, agile project management, managing large international projects, project governance, project risk and uncertainty management, project time and schedule management, management of innovative projects.

Mode of delivery:
The tuition will be implemented as blended teaching (web-based teaching and face-to-face teaching).

Learning activities and teaching methods:
Lectures, web-based-lectures and workshops 26h, group exercises and cases 66h, self-study 42h.

Target group:
Industrial Engineering and Management students.

Prerequisites and co-requisites:
555285A Basic course in project management.
Recommended optional programme components:

- 

Recommended or required reading:
Lecture materials and reading materials (articles, book chapters) related to each lecture.

Assessment methods and criteria:
This course utilises continuous assessment. The grading is based on case assignments solved in groups and discussed during the lecture, and group assignment that is presented and discussed in the workshops. Since the implementation of the cases and group work vary, the assessment methods and criteria will be defined at the beginning of the course.

Grading:
The course utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible:
Assistant professor Kirsi Aaltonen

Working life cooperation:
The course includes guest lectures from industry.

Other information:
Substitutes course 555381S Project Leadership.

H453222: Modules of the option RF Engineering, 70 - 90 cp

Validity: 01.08.2017 -
Form of study: Other Entity
Type: Study module
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Opintokohteen kielet (E): Finnish

No course descriptions.

Compulsory

A451226: Module of the option, RF Engineering, 36 - 71 cp

Validity: 01.08.2017 -
Form of study: Module of the Option
Type: Study module
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Opintokohteen kielet (E): Finnish

No course descriptions.

Obligatory studies: basic and advanced module, tot. 36 ECTS cr
**521401S: Electronics Design II, 6 cp**

- **Validity:** 01.08.2017 -
- **Form of study:** Advanced Studies
- **Type:** Course
- **Unit:** Electrical Engineering DP
- **Grading:** 1 - 5, pass, fail
- **Teachers:** Ilkka Nissinen, Jan Nissinen
- **Opintokohteen kielet (E):** English

**ECTS Credits:**
6 ECTS

**Language of instruction:**
In Finnish (In English if needed).

**Timing:**
Autumn, period 1

**Learning outcomes:**
Student
1. should be able to explain the structures and operating principles of the passive and active (BJT and MOS) components available for use in modern IC technologies
2. should be able to analyze and design integrated electronic blocks based on these components, such as operational amplifiers, comparators and sampling circuits
3. should be able to estimate and minimize the effects of noise in electrical circuits
4. should be able to explain the terminology used with DA and AD conversion and converters
5. should be able to analyze and outline the main architectural principles and also to evaluate the characteristics of DA and AD converters

**Contents:**
Modeling of BJT and MOS transistors, CMOS and BJT building blocks especially as IC-realizations, noise and analysis of noise, internal structure of operational amplifiers, critical parameters, comparators, S/H-circuits, structures and properties of A/D and D/A converters.

**Mode of delivery:**
Face-to-face teaching

**Learning activities and teaching methods:**
Face-to-face teaching: Lectures 30h, exercises 20h. Self study: a small design work 30h. Learning without guidance either privately or in a group 80h.

**Target group:**
Students of Electrical engineering. Other students of the University of Oulu may also participate.

**Prerequisites and co-requisites:**
Principles of electronics design, Electronics design I

**Recommended optional programme components:**
-

**Recommended or required reading:**

**Assessment methods and criteria:**
The course unit is passed by a final exam or by a two midterm exams and a passed design work. Read more about [assessment criteria](#) at the University of Oulu webpage.

**Grading:**
The course unit utilizes a numerical grading scale 1-5.

Person responsible:
Ilkka Nissinen

Working life cooperation:
No

Other information:
-

521348S: Statistical Signal Processing 1, 5 cp

Validity: 01.08.2016 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Janne Lehtomäki, Juntti, Markku Johannes

Opintokohteen kielet (E): Finnish
Leikkaavuudet (E):
521484A Statistical Signal Processing 5.0 cp

ECTS Credits:
5 ECTS

Language of instruction:
English

Timing:
The course is held in the autumn semester, during period 1. It is recommended to complete the course at the 1st semester of the master studies.

Learning outcomes:
Upon completion the student
1. knows the key tools of linear algebra and optimization and can apply them in solving signal processing problems.
2. understands the key concepts in estimation theory such as the classical and Bayesian framework.
3. masters the most important estimation principles such as minimum variance, maximum likelihood, least squares and minimum mean square error estimators.
4. can derive an estimator for a given criterion and basic data models.
5. can use the methodology of estimation theory to analyze the performance of estimators
6. understands the basics of detection and classification theory: hypothesis testing, receiver operating characteristics (ROC), matched filtering, estimator-correlator

Contents:
Review of probability, linear algebra, random variables and stochastic processes; SVD (Singular value decomposition), QR decomposition, estimation theory, minimum variance unbiased estimator, Cramer-Rao lower bound, linear models, general minimum variance unbiased estimation, best linear unbiased estimators, maximum likelihood estimation, least squares estimation, Bayesian estimation, linear Bayesian estimation, Wiener filters, statistical decision theory, receiver operating characteristics, hypothesis testing, matched filter, estimator-correlator.

Mode of delivery:
Face-to-face teaching and e-learning tool usage

Learning activities and teaching methods:
Face-to-face-teaching (lectures and exercises) 50h, Matlab simulation exercises in groups 30 h, independent work & passed assignment 50 h.

Target group:
Electrical, communications and computer science and engineering students.

Prerequisites and co-requisites:
The required prerequisite is the completion of the following courses prior to enrolling for the course: 031080A Signal Analysis, 031021P Probability and Mathematical Statistics, 031078P Matrix Algebra, 521330A Telecommunication Engineering.

Recommended optional programme components:
521323S Wireless communications I and 031051S Numerical Matrix Analysis are recommended to be taken in parallel.

Recommended or required reading:
Parts from books:
5. Other literature, lecture notes and material.

Assessment methods and criteria:
Completing the simulation project tasks, and a mid-term exam during the course. The mid-term exams can be retaken by a final exam later. In the final grade of the course, the weight for the examination is 0.7 and that of project report 0.3.
Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course utilizes a numerical grading scale 1-5. In the numerical scale zero (0) stands for a fail.

Person responsible:
Janne Lehtomäki and Markku Juntti

Working life cooperation:
No

Other information:
-

521395S: Wireless Communications I, 5 cp

Validity: 01.08.2019 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Timo Kokkonen, Jari Iinatti
Opintokohteen kielet (E): English
Leikkaavuudet (E):

521395S-01 Wireless Communications I, Exam 0.0 cp
521395S-02 Wireless Communications I, Exercise 0.0 cp
521323S Wireless Communications 2 5.0 cp
521323S-02 Wireless Communications I, Exercise 0.0 cp
ECTS Credits:
5

Language of instruction:
English

Timing:
Fall, period 1

Learning outcomes:
Student
1. can analyze the performance of multilevel digital modulation methods in AWGN channel
2. can explain the effect of fading channel on the performance of the modulation method and can
   analyze the performance
3. recognizes and understand suitable diversity methods for fading channel and related combining
   methods
4. can understand and explain coding methods for wireless channels
5. recognizes different wideband systems
6. understands the cellular system principle

Contents:
Radio channel models, digital modulation and detection methods, carrier and symbol
synchronization, performance of digital modulation in AWGN and fading channel, diversity
 techniques, coding for wireless channel, multicarrier modulation, spread spectrum, cellular
systems.

Mode of delivery:
Face-to-face teaching

Learning activities and teaching methods:
Lectures and exercise (total 40 hours) and the compulsory design work with a simulation program
(20 h)

Target group:
1st year WCE students and M.Sc. students (i.e., 4th year in ECE degree programme)

Prerequisites and co-requisites:
521330A Telecommunication Engineering

Recommended optional programme components:
-

Recommended or required reading:

Assessment methods and criteria:
The course is passed with minor exams (only during lecture period) or with final exam; and the
accepted design work report. In the final grade of the course, the weight for the examination(s) is
0.6 and that for the design work report 0.4.
Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible:
Jari Iinatti / Timo Kokkonen

Working life cooperation:
521326S: Radio Engineering 1, 5 cp

Validity: 01.08.2015 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Aarno Pärssinen, Risto Vuohtoniemi
Opintokohteen kielet (E): Finnish
Leikkaavuudet (E):
  521326S-01  Radio Engineering  0.0 cp
  521326S-02  Exercise work, Radio engineering 1  0.0 cp
  521335S-01  Radio engineering, partial credit  0.0 cp
  521335S-02  Radio engineering, partial credit  0.0 cp
  521335S  Radio Engineering  6.0 cp

ECTS Credits:
5
Language of instruction:
English
Timing:
Fall, period 2
Learning outcomes:
1. learns key components of radio transceivers used in wireless communications including LTE and 5G.
2. knows different kind of impedance matching methods and can design the impedance matching network using lumped components and microstrip lines. A student can also explain factors, which are limiting the bandwidth of impedance matching networks. Smith chart (admittance/impedance chart).
3. will be able to design a low noise RF amplifier. The amplifier is designed that the noise figure is minimized or the gain is maximized. The impedance matching can also be made for the constant gain.
4. knows single sideband and double sideband noise in mixers. A student will be able to design balanced and double balanced mixer and knows the advantages and the disadvantages of these mixers.
5. will be able to design passive microwave components like a Wilkinson power divider, a directional coupler and hybrids.
6. can explain basic principles of RF-oscillators. A student can design a cross-coupled oscillator and voltage controlled oscillator.
7. knows concept of noise, non-linearity and dynamic range as used in radio frequency communications.
8. can classify power amplifiers and will be able in the basic case design the matching network for a power amplifier.

Contents:
Noise, non-linearity, impedance matching using lumped components, microstrip matching networks, low noise amplifier (LNA) design, active and passive mixers design, Wilkinson power dividers, directional couplers, hybrids, automatic gain control (AGC), cross-coupled oscillator, voltage controlled oscillators, power amplifier design.

**Mode of delivery:**
Face-to-face teaching

**Learning activities and teaching methods:**
Lectures 24 h, exercises 16 h and the compulsory RF design work with ADS simulation software (20 h).

**Target group:**
1st year M.Sc. and WCE-RF students. 2nd year M.Sc. (Telecom.) and WCE-RAN students.

**Prerequisites and co-requisites:**
Basics of Radio Engineering

**Recommended optional programme components:**

**Recommended or required reading:**

**Assessment methods and criteria:**
The course is passed with a final examination and the accepted simulation work report. In the final grade of the course, the weight for the examination is 0.75 and that for the simulation work 0.25. Read more about assessment criteria at the University of Oulu webpage.

**Grading:**
The course unit utilizes a numerical grading scale 1-5.

**Person responsible:**
Risto Vuohioniemi, Aarno Pärssinen.

**Working life cooperation:**
No

**Other information:**

521324S: Statistical Signal Processing II, 5 cp

**Validity:** 01.08.2015 -
**Form of study:** Advanced Studies
**Type:** Course
**Unit:** Electrical Engineering DP
**Grading:** 1 - 5, pass, fail
**Teachers:** Juntti, Markku Johannes
**Opintokohteen kielet (E):** English

Leikkaavuudet (E):
- 521373S Statistical Signal Processing 2 6.0 cp
- 521373S-01 Statistical Signal Processing 2, exam 0.0 cp
- 521373S-02 Statistical Signal Processing 2, exercise work 0.0 cp

**ECTS Credits:**
5
Language of instruction:
English

Timing:
The course is held in the spring semester, during period 3. It is recommended to complete the course at the 1st spring semester of the master studies.

Learning outcomes:
Upon completion the student will
1. understand the key design problems and constraints of the design of typical estimation problems in statistical signal processing.
2. have the skills to apply estimation, detection and other statistical signal processing methods to solve practical problems in communications.
3. can use linear algebra, basics of optimization and statistical signal processing to derive algorithms with statistical models or driven by data.
4. can use numerical analysis to approximate optimal algorithms with iterative solutions including (un)supervised adaptive algorithms.
5. understands the basic requirements for the convergence of an iterative and adaptive algorithm.
6. can model the operation of a transceiver using Matlab and other simulators to assess the performance of transceiver algorithms.

Contents:

Mode of delivery:
Face-to-face teaching and e-learning tool usage

Learning activities and teaching methods:
Face-face-teaching (lectures and exercises) 50h, Matlab simulation exercises in groups 30 h, independent work & passed assignment 50 h.

Target group:
Electrical, communications and computer science and engineering students.

Prerequisites and co-requisites:
The required prerequisite is the completion of the following courses prior to enrolling for the course: 031080A Signal Analysis, 031021P Probability and Mathematical Statistics, 031078P Matrix Algebra, 521330A Telecommunication Engineering, 521348S Statistical Signal Processing I. The recommended prerequisite is the completion of 521323S Wireless Communications I, 031025A Introduction to Optimization and 031051S Numerical Matrix Analysis.

Recommended optional programme components:
521317S Wireless communications II is recommended to be taken in parallel.

Recommended or required reading:
Parts from books:
6. Other literature, lecture notes and material.

Assessment methods and criteria:
Completing the simulation project tasks, and a mid-term exam during the course. The mid-term exams can be retaken by a final exam later. In the final grade of the course, the weight for the examination is 0.6 and that of project report 0.4.

Read more about [assessment criteria](#) at the University of Oulu webpage.

**Grading:**
The course utilizes a numerical grading scale 1-5. In the numerical scale zero (0) stands for a fail.

**Person responsible:**
Markku Juntti and Janne Lehtomäki

**Working life cooperation:**
No

**Other information:**
-

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521225S: RF Components and Measurements, 5 cp

**Form of study:** Advanced Studies  
**Type:** Course  
**Unit:** Electrical Engineering DP  
**Grading:** 1 - 5, pass, fail  
**Teachers:** Teirikangas, Merja Elina

**Opintokohteen kielet (E):** Finnish

**ECTS Credits:**
5 ECTS credits / 132,5 hours of work

**Language of instruction:**
Finnish. English, if there are at least 3 international students in class.

**Timing:**
The course is held in the 4th period. It is recommended to complete the course during Master level studies.

**Learning outcomes:**
1. After completing the course the student has knowledge of the behavior of passive components at RF frequencies, knows the fabrication methods of components and is also able to apply the knowledge to practical applications.

2. The student also knows the operating principles of transfer lines, antennas and filters and of their design.

3. The student can apply the fundamentals of RF and microwave techniques to measurements, is able to make the measurements of RF components, has knowledge of the operating principles of RF region measurement equipment and is able to compare the usability of different measurement equipment.

4. The student knows how to perform typical measurements of RF region magnitudes (power, frequency, impedance and noise).

**Contents:**
Fundamentals of RF and microwave techniques, components in microwave circuits, measurement instruments, measuring of power, frequency, impedance and noise, time-domain and active circuit measurements.

**Mode of delivery:**
Face-to-face teaching, independent design exercises and laboratory exercises.
Learning activities and teaching methods:
Lectures 24 h, design exercises 20 h, laboratory exercises 20 h, independent work 68.5 h.

Target group:
Masters students on electrical engineering

Prerequisites and co-requisites:
The recommended prerequisite is the completion of the following courses prior to enrolling for the course unit: Electronic Components and Materials, Electronic Measurement Techniques, Basics of Radio Engineering.

Recommended optional programme components:
The course is an independent entity and does not require additional studies carried out at the same time.

Recommended or required reading:

Assessment methods and criteria:
Final exam, design exercises and laboratory exercises.
Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible:
Merja Teirikangas

Working life cooperation:
No.

Other information:

521405A: Electronic System Design, 5 cp

Form of study: Intermediate Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Kari Määttä
Opintokohteen kielet (E): Finnish

ECTS Credits:
5

Language of instruction:
English/Finnish.

Timing:
Period 1

Learning outcomes:
1. is able to choose the optimum method of the choices presented in the course in the field of power supply, thermal design, grounding, and routing of the high speed signals.
2. is able to calculate problems, caused by electrical disturbances, crosstalk and non-idealities of electrical components.
3. can calculate reliability of an electrical device or system.
4. The main goal of the course is to introduce methods and techniques needed in designing larger electronic entities such as equipment and systems.

**Contents:**
Power supplies, thermal design, grounding, transmission of fast signals by using transmission lines, electrical disturbances, crosstalk, non-idealities of electrical components.

**Mode of delivery:**
Face-to-face teaching.

**Learning activities and teaching methods:**
The course includes 30 h of lectures and 20 h of exercises.

**Target group:**
Primarily in electrical engineering students. Other University of Oulu students can complete the course.

**Prerequisites and co-requisites:**
Both Principles of Electronics Design and Analogue Electronics I must have been accepted.

**Recommended optional programme components:**
The course is an independent entity and does not require other studies carried out at the same time.

**Recommended or required reading:**

**Assessment methods and criteria:**
The course is passed by means of a final exam.
Read more about [assessment criteria](#) at the University of Oulu webpage.

**Grading:**
The course unit utilizes a numerical grading scale 0 - 5. In the numerical scale 0 stands for a fail.

**Person responsible:**
Kari Määttä

**Working life cooperation:**
No.

**Other information:**
-

A451297: Advanced Module, Radio engineering, 36 - 42 cp

- **Validity:** 01.08.2019 -
- **Form of study:** Advanced Module
- **Type:** Study module
- **Unit:** Electrical Engineering DP
- **Grading:** 1 - 5, pass, fail
- **Opintokohteen kielet (E):** Finnish

No course descriptions.

Radio engineering - advanced module
521435S: Electronics Design III, 6 cp

**Form of study:** Advanced Studies  
**Type:** Course  
**Unit:** Electrical Engineering DP  
**Grading:** 1 - 5, pass, fail  
**Teachers:** Ilkka Nissinen  
**Opintokohteen kielet (E):** Finnish  

**ECTS Credits:**  
6  

**Language of instruction:**  
In Finnish (English as a book examination)  

**Timing:**  
Autumn, period 2  

**Learning outcomes:**  
1. On completion of the study module students should be able to detail the advantages of differential signal processing in IC realizations and  
2. to analyze and design differential amplifiers and other electronic blocks for implementation in an IC environment.  
3. They should be able to explain how an SC (switched capacitor) technology functions and to apply such a technology to sampling and filtering.  
4. They should also be able to describe the principles for realizing continuous filters in IC technologies, to explain the principles of the delta–sigma technology  
5. and to apply it for realizing integrated DA and AD converters.  
6. They should be able to account for the functioning, use and architecture of a phase-locked loop,  
7. to explain the functioning of an MOS transistor in the area of weak inversion and to indicate how use can be made of this functional area in circuit design.  

**Contents:**  
Advanced operational amplifier topologies, especially differential ones, bandgap and PTAT bias circuits and references, problems related to the design of multi-stage amplifiers (output stages, LP/LV implementations), signal sampling and error sources related to it, SC-techniques (especially in filters), implementation principles of continuous time IC filters, DS techniques in general and particularly in AD/DA converters, operations with frequency/phase domain signals, design of IC layout.  

**Mode of delivery:**  
Face-to-face teaching  

**Learning activities and teaching methods:**  
Lectures 30h and Exercises 20 h and 4h layout demo. Self-study or in a group of two persons: laboratory exercise 36 h (CAD tools used in IC design and familiarization into the complete analogue IC design flow) and learning without guidance either privately or in a group 69 h.  

**Target group:**  
Electrical Engineering students and other Students of the University of Oulu.  

**Prerequisites and co-requisites:**  
Electronics Design II, Filters, Introduction to Microfabrication Techniques (recommended).  

**Recommended optional programme components:**  
The course is an independent entity and does not require additional studies carried out at the same time  

**Recommended or required reading:**  
Lecture notes

**Assessment methods and criteria:**
Passed final exam or 2 midterm exams and exercise work. Read more about [assessment criteria](#) at the University of Oulu webpage.

**Grading:**
Numerical grading scale 1-5.

**Person responsible:**
Ilkka Nissinen

**Working life cooperation:**
No

**Other information:**
-

**521327S: Radio Engineering II, 6 cp**

**Validity:** 01.08.2015 -

**Form of study:** Advanced Studies

**Type:** Course

**Unit:** Electrical Engineering DP

**Grading:** 1 - 5, pass, fail

**Teachers:** Risto Vuohtoniemi, Aarno Pärssinen

**Opintokohteen kielet (E):** English

**Leikkaavuudet (E):**
- 521375S Design of Tranceivers 5.0 cp
- 521375S-01 Design of tranceivers, partial credit 0.0 cp
- 521375S-02 Exercise work, Radio Engineering II 0.0 cp

**ECTS Credits:**
6 ECTS cr

**Language of instruction:**
English

**Timing:**
Spring, period 3

**Learning outcomes:**
1. understands radio system and RF design for modern wireless equipment like cellular phones.
2. recognizes the blocks of a transceiver and can explain the operating principle of a transceiver.
3. can classify different architectures used in a single and a multi-antenna transceiver and understand the basis for them.
4. will be able to define parameters used in the transceiver system level design and can design a transceiver at the system level so that the requirements for the system are fulfilled.
5. knows nonlinear distortion and can design the automatic gain control in the system level.
6. will be able to explain factors, which are important for the selection of D/A- and A/D-converters and can derive various methods to create the in phase and the quadrature components of a received signal.

7. understands the principles of frequency synthesis in a transceiver.
8. understands principles of key implementation technologies of radio transceivers and relation to electronics.

Contents:
Designing a transceiver at the system level, transceiver architectures, performance characteristics of transceivers, nonlinearities, factors which limit the performance of a transceiver, placement of the A/D-converter in a receiver, frequency synthesis, design and implementation examples.

Mode of delivery:
Face-to-face teaching

Learning activities and teaching methods:
Lectures 32 h and the compulsory design exercise with ADS simulation software (54 h).

Target group:
1st year M.Sc. and WCE-RF students

Prerequisites and co-requisites:
Radio Engineering I

Recommended optional programme components:
-

Recommended or required reading:

Assessment methods and criteria:
The course is passed with a final examination and the accepted simulation work report. In the final grade of the course, the weight for the examination is 0.75 and that for the simulation work 0.25. Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course unit utilizes a numerical grading scale 1-5.

Person responsible:
Risto Vuotioniemi, Aarno Pärssinen.

Working life cooperation:
No

Other information:
-

521075S: Microelectronics Packaging Technologies, 5 cp

Validity: 01.08.2015 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Sami Myllymäki
Opintokohteen kielet (E): Finnish

ECTS Credits:
5

**Language of instruction:**
Finnish

**Timing:**
3rd period

**Learning outcomes:**
1. Upon completing the course student can explain how electronics packaging technology has since invention of transistors to current date, and can estimate how this development is going to continue in future.

2. The student can describe can explain what is meant by microjoining techniques and what are the pros and cons of these.

3. The student can tell what different kind of materials, and why, are used in IC packaging technology.

4. The student can explain what is meant with system level packaging and how the strong miniaturization on IC requires new system level packaging techniques to be developed.

5. He can explain why active and passive components are being, more and more, embedded to be a part of the circuit board.

6. In addition he can explain why and how optoelectronics will be migrate towards circuit board and components on it.

**Contents:**

**Mode of delivery:**
Face to face teaching

**Learning activities and teaching methods:**
Lecturing 24 h, practical work 12 h.

**Target group:**
Primarily major students of electrical engineering.

**Prerequisites and co-requisites:**
Recommended Introduction to Microfabrication Techniques.

**Recommended optional programme components:**
The course is an independent entity and does not require additional studies carried out at the same time.

**Recommended or required reading:**

**Assessment methods and criteria:**
The course is completed with the final exam and finished course work.

**Grading:**
The course unit utilizes a numerical grading scale 1-5.

**Person responsible:**
Sami Myllymäki
Working life cooperation:
No

Other information:
-

521388S: Antennas, 5 cp

Validity: 01.08.2015 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Markus Berg

Opintokohteen kielet (E): English
Leikkaavuudet (E):
521380S Antennas 4.0 cp
521380S-01 Antennas, partial credit 0.0 cp
521380S-02 Antennas, partial credit 0.0 cp

ECTS Credits:
5 ECTS credits / 135 hours of work

Language of instruction:
English

Timing:
Spring, period 4

Learning outcomes:
After completing the course, student
1. knows antenna terminology and understands the role of antennas as a part of different radio systems.
2. is familiar with the theories explaining the electromagnetic radiation of usual antenna types and antenna arrays.
3. will be able to design wire antennas, micro strip antennas and antenna arrays for different radio systems.
4. will be able to design and analyze various antenna types and arrays using 3D electromagnetic simulation software.

Contents:

Mode of delivery:
Face-to-face teaching

Learning activities and teaching methods:
Lectures and exercises 40 h / Compulsory antenna design work with an electromagnetic simulation 25 h / Self-study 70 h

Target group:
1st or 2nd year M.Sc. and WCE students

**Prerequisites and co-requisites:**
The required prerequisite is the completion of the following courses prior to enrolling for the course: Basics of Radio Engineering 521384A

**Recommended optional programme components:**
The course is an independent entity and does not require additional studies carried out at the same time.

**Recommended or required reading:**

**Assessment methods and criteria:**
The course is passed with a final examination and the accepted design work report. In the final grade of the course, the weight for the examination is 0.5 and that for the design work 0.5. Read more about [assessment criteria](#) at the University of Oulu webpage.

**Grading:**
The course utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

**Person responsible:**
Markus Berg

**Working life cooperation:**
No

**Other information:**

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**521402S: Telecommunications Circuit Design, 6 cp**

**Validity:** 01.08.2017 -

**Form of study:** Advanced Studies

**Type:** Course

**Unit:** Electrical Engineering DP

**Grading:** 1 - 5, pass, fail

**Teachers:** Rahkonen, Timo Erkki

**Opintokohteen kielet (E):** Finnish

**ECTS Credits:**
6 ects / 42 contact hours + design excercise

**Language of instruction:**
English/Finnish

**Timing:**
Autumn, 1st period of the last year of studies

**Learning outcomes:**
After completing the course the student
- knows the most usual schematic structures and dimensioning principles of typical telecommunication circuit blocks
- can sketch the spectral effects of non-linear and time-varying circuit blocks
- can evaluate the performance of the available IC process node

**Contents:**
The course gives the background needed in the design of RFICs and other analog telecommunication circuit blocks.

**Mode of delivery:**
Face-to-face teaching

**Learning activities and teaching methods:**
28 hours of lectures, 14 of exercises, and a relatively large design task.

**Target group:**
Last year MSc students with strong analog design background

**Prerequisites and co-requisites:**
Strong background in analog transistor level design is required.

**Recommended optional programme components:**
Needs electronics design 2-3 background

**Recommended or required reading:**
Handouts

**Assessment methods and criteria:**
Graded based on the final exam. The design exercise needs to be passed.

**Grading:**
Numerical scale 0-5. 0 is fail, 5 the best.

**Person responsible:**
Prof. Timo Rahkonen

**Working life cooperation:**
The topics are strongly related to the skills needed in the industry

**Other information:**
The course is the last advanced course in analog design, and requires the basic knowledge of transistor level analog design and IC design.

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_Obligatory, Radio engineering - advanced module, Choose 521322S Telecommunication engineering project or 521300S Electronics design and construction exercise_

**521322S: Telecommunication Engineering Project, 5 cp**

**Validity:** 01.08.2015 -

**Form of study:** Advanced Studies

**Type:** Course

**Unit:** Electrical Engineering DP

**Grading:** 1-5, pass, fail

**Teachers:** Markus Berg, Saarnisaari, Harri Tapani

**Opintokohteen kielet (E):** Finnish

**Leikkaavuudet (E):**

- 521387S Telecommunication Engineering Project 4.0 cp

**ECTS Credits:**
5 ECTS credits / 135 hours of work

**Language of instruction:**
English/Finnish

**Timing:**
Fall or Spring, periods 1-4
Learning outcomes:

After completing the course student can
1. depending on the work subject, either solve, design, construct, measure, simulate, test or analyze limited telecommunication and radio system and sub-system problems.
2. apply the technical knowledge acquired from advanced sources into practical engineering tasks.
3. document technical and scientific results.

Contents:

Varies depending on the topic.

Mode of delivery:

Independent work.
If you would like to take the course, you can contact the course person responsible.

Learning activities and teaching methods:

The design exercise is done in a group of one or two students depending of work's difficulty. The design exercise can be simulation or implementation work. The work can be defined by the Department of Communications Engineering or by industry. In the later case a proposal must be submitted to the teacher before beginning of the work. Also, student must meet the schedule and deadlines given by a supervisor before starting the work. In preparing the work report document the writing instructions of DCE department's diploma thesis must be followed.

Target group:

1st or 2nd year M.Sc. and WCE students

Prerequisites and co-requisites:

Depending on the subject: advanced courses dealing with telecommunication systems, digital communications, digital signal processing or/and radio engineering.

Recommended optional programme components:

The course is an independent entity and does not require additional studies carried out at the same time.

Recommended or required reading:

Varies depending on the topic.

Assessment methods and criteria:

Written work report.
Read more about assessment criteria at the University of Oulu webpage.

Grading:

The course utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible:

Markus Berg / Harri Saarnisaari

Working life cooperation:

No

Other information:

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Opintokohteen kielet (E): Finnish
Leikkaavuudet (E):
   521441S   Electronics Design and Construction Exercise   6.5 cp

ECTS Credits:
6

Language of instruction:
Finnish, English

Timing:
Periods 1-4

Learning outcomes:
1 is able to carry out all the stages needed to develop an electronic circuit or device starting from independent creation and design work to realization, testing and technical documentation.
2 is able to use independently without any help professional methods, software packages, measurement devices and tools.
3 Objective: To familiarize the student with independent electrical circuit and system design and with the methods and tools used in the design process. The course prepares the student for the diploma work in the area of circuits and system design.

Contents:
Design and construction of an electronic device or a part of a device according to the given specification. The task can be part of an industrial research or a product design project or part of the research project going on in Electronics or other laboratory. The subject of the work can be own suggestion of the student or a pre-selected course subject, which enables comprehensive training of skills needed for the design of a modern electronic device.

Mode of delivery:
Independent work.

Learning activities and teaching methods:
Independent design and construction work 180h

Target group:
Primarily in electrical engineering students. Other University of Oulu students can complete the course

Prerequisites and co-requisites:
Student must have passed following courses: Analogue Electronics I-II, Digital Techniques I-II, Electronic System Design and Filter Theory.

Recommended optional programme components:
The course is an independent entity and does not require other studies carried out at the same time.

Recommended or required reading:
Not defined

Assessment methods and criteria:
The task can be carried out by a student or by a team of two students. The grade will be decided on the basis of the statement of the instructor, realization of the device and the report provided by the student.

Grading:
The course unit utilizes a numerical grading scale 0 - 5. In the numerical scale 0 stands for a fail.

Person responsible:
Kari Määttä

Working life cooperation:
Optional studies: please select courses so that the minimum extent is 120 ECTS.

521386S: Radio Channels, 5 cp

Validity: 01.08.2011 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Pekka Kyösti, Markus Berg
Opintokohteen kielet (E): English

ECTS Credits:
5 ECTS credits / 130 hours of work
Language of instruction:
English
Timing:
Autumn, period 2.
Learning outcomes:
After completing the course, student
1. will be able to define what the radio channel is and is able to distinguish it into modelable parts.
2. knows different radio wave propagation mechanisms.
3. can apply physical and empirical radio channel models.
4. is able to analyse which are the dominating propagation mechanisms in different environments.
5. will know how to measure the properties of different radio channels.

Contents:

Mode of delivery:
Face-to-face teaching
Learning activities and teaching methods:
Lectures 24 h / Exercises 12 h / compulsory laboratory work 25 h / Self-study 74 h.
Target group:
1st or 2nd year M.Sc. and WCE students

Prerequisites and co-requisites:
The required (or recommended) prerequisite is the completion of the following courses prior to enrolling for the course: Basics of Radio Engineering, Signal Analysis

Recommended optional programme components:
The course is an independent entity and does not require additional studies carried out at the same time.

**Recommended or required reading:**

**Assessment methods and criteria:**
The course is passed with a final examination and the accepted laboratory work report. Read more about assessment criteria at the University of Oulu webpage.

**Grading:**
The course utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

**Person responsible:**
Markus Berg / Pekka Kyösti

**Working life cooperation:**
No

**Other information:**
-

521328A: Simulations and Tools for Telecommunications, 5 cp

**Validity:** 01.08.2015 -

**Form of study:** Intermediate Studies

**Type:** Course

**Unit:** Electrical Engineering DP

**Grading:** 1 - 5, pass, fail

**Teachers:** Johanna Vartiainen

**Opintokohteen kielet (E):** Finnish

**Leikkaavuudet (E):**
- 521369A Simulations and Tools for Telecommunications 3.0 cp
- 521369A-01 Simulations and Tools for Telecommunications, exam 0.0 cp
- 521369A-02 Simulations and Tools for Telecomm. exercise 0.0 cp

**ECTS Credits:**
5

**Language of instruction:**
Finnish

**Timing:**
Fall, period 2

**Learning outcomes:**
1. A student recognizes problems and limitations related to simulations.
2. She/he can select a suitable simulation method and knows how to validate the model.
3. Student knows how to generate signals, random numbers and noise.
4. She/he knows how to model fading channels.
5. A student knows how to make Monte-Carlo simulations at the baseband level and can estimate confidence level of simulation results.
6. She/he can explain principles of network level simulations.

7. A student knows basics of one or two fundamental simulation programs

Contents:
Simulation methods, modelling communication systems with simulations, confidence limits of simulation, noise generation and modelling of fading channel. A simple baseband simulation example. Basics of MATLAB and OPNET simulation software (these could vary depending on needs/availability).

Mode of delivery:
Face-to-face teaching

Learning activities and teaching methods:
Lectures 24 h (including program introductions), and the compulsory assignment with a simulation program (40 h).

Target group:
3rd year bachelor's degree students and M.Sc. students

Prerequisites and co-requisites:
Telecommunication Engineering

Recommended optional programme components:
The course is an independent entity and does not require additional studies carried out at the same time.

Recommended or required reading:

Assessment methods and criteria:
The course is passed with a final examination and the accepted simulation work report. The final grade is based on exam. Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course unit utilizes a numerical grading scale 1-5.

Person responsible:
Johanna Vartiainen

Working life cooperation:
No

Other information:
-

521340S: Communications Networks I, 5 cp

Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Mika Ylianttila
Opintokohteen kielet (E): English

ECTS Credits:
5 ECTS cr
Language of instruction:
English

Timing:
Fall, period 2

Learning outcomes:
1. Students understand how the modern communications networks have evolved and how the architecture has changed through the recent paradigm shift towards software-centric communications.
2. Students are able to describe the basic system architecture elements of mobile networks, and understands the significance of emerging technologies such as Network Function Virtualization (NFV), Software Defined Networking (SDN), and core network functionalities such as Evolved Packet Core (EPC).
3. Students can describe the main principles of mobility management, network management and orchestration, and network security, and can apply and solve related engineering problems.
4. Students know the basic properties of routing algorithms, and can use graph theory to solve network routing problems.
5. Students are able to simulate different types of networks in simulation environments and solve basic network programming problems. Upon completing the required coursework, students understand the basic functionalities in TCP/IP protocol stack.

Contents:
Communications architecture in mobile, wireless local area and personal area networks. Introduction to cloud and edge computing, network function virtualization and software defined networking. Basic principles of mobility management, network security, network management and orchestration. The goal is to present the basics of the modern communications architectures, and their technical implementation.

Mode of delivery:
Face-to-face teaching.

Learning activities and teaching methods:
Lectures 30 h and the compulsory design work (15 h). Design work can be done alternatively either as NS-2 simulation or TCP/IP programming exercise. Design work instructions are provided in digital learning environment (Optima / Moodle).

Target group:
1st year M.Sc. and WCE students

Prerequisites and co-requisites:
-

Recommended optional programme components:
The course is an independent entity and does not require additional studies carried out at the same time.

Recommended or required reading:
Software Defined Mobile Networks (SDMN): Beyond LTE Network Architecture, M Liyanage, A Gurtov, M Ylianttila – 2015; A comprehensive Guide to 5G Security, M Liyanage, I Ahmad, A Abro, A Gurtov, M Ylianttila – 2018; In addition, selected supportive online reading materials from recent standards and publications are provided in digital learning environment (Optima / Moodle).

Assessment methods and criteria:
The course is passed with a final examination and the accepted design work report. The final grade is based on examination.
Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course unit utilizes a numerical grading scale 1-5.

Person responsible:
Mika Ylianttila


**Working life cooperation:**
No

**Other information:**
- 

**521349S: Wireless Communications II, 5 cp**

**Form of study:** Advanced Studies

**Type:** Course

**Unit:** Electrical Engineering DP

**Grading:** 1 - 5, pass, fail

**Teachers:** Antti-Heikki Tölli

**Opintokohteen kielet (E):** English

**ECTS Credits:**
5

**Language of instruction:**
English

**Timing:**

Spring, periods 3-4

**Learning outcomes:**

1. The student is familiarised with the channel capacity as the fundamental performance measure of wireless communication links, and can explain the effect of fading channel on the capacity in a single-user single-antenna scenarios.
2. The student understands the basic principles for multiuser communications in fading channels, apprehends the notion of capacity region for multi-access and broadcast channels, and is familiarised with different practical multiple access, random access and scheduling methods.
3. The student is acquainted with core principles of adaptive transmission, which requires accurate channel estimates at the receiver and a reliable information exchange mechanisms between the receiver and transmitter. Practical variable-rate variable-power MQAM modulation techniques for fading channels are introduced.
4. The student understands the principles of transmitter and receiver design in the presence of channel distortion. The student is familiarised with various (adaptive) equalization solutions to combat intersymbol interference.
5. Finally, the student is acquainted with the capacity optimal multi-antenna transmission and reception scheme, as well as, with basic multiantenna space-time coding schemes in a single-user multiple-input multiple-output (MIMO) communications scenario.

**Contents:**

Capacity of wireless channels, multiuser communications, adaptive modulation and coding, equalization, point-to-point MIMO communications and space-time coding.

**Mode of delivery:**

Face-to-face teaching

**Learning activities and teaching methods:**

Lectures and exercise (total 40 hours) and the compulsory design work with a simulation program (20 h).

**Target group:**

1st year WCE students and M.Sc. students (i.e., 4th year in ECE degree programme).

**Prerequisites and co-requisites:**
In addition to courses “521395S Wireless Communications I”, 521348S “Statistical Signal Processing I”,
031025A “Introduction to optimization” and 031051S “Numerical matrix analysis”, a working knowledge
in digital communications, random processes, linear algebra, matrix manipulation and detection theory
is required.

**Recommended optional programme components:**

Prior knowledge of 521390S Information Theory and 521392S Convex Optimisation is very useful but not
mandatory. The course 521324S Statistical Signal Processing II is recommended to be taken in parallel.

**Recommended or required reading:**

D. N. C. Tse and P. Viswanath, Fundamentals of Wireless Communication. Cambridge University Press,
2005, Chapters 3-7.

Supporting material: Cover & Thomas, "Elements of Information Theory", John Wiley & Sons; Boyd &

**Assessment methods and criteria:**

The course is passed with a final examination and the accepted simulation work report. The final grade is
a weighted sum of exam (70%), homework (20%), and work report (10%).

**Grading:**

The course unit utilizes a numerical grading scale 1-5.

**Person responsible:**

Antti Tölli

**Working life cooperation:**

No

**Other information:**

Course replaces the old course 521317S Wireless Communications II (8cr).

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**521289S: Machine Learning, 5 cp**

**Validity:** 01.08.2015 -

**Form of study:** Advanced Studies

**Type:** Course

**Unit:** Computer Science and Engineering DP

**Grading:** 1 - 5, pass, fail

**Teachers:** Tapio Seppänen

**Opintokohteen kielet (E):** Finnish

**Leikkaavuudet (E):**

- 521497S-01 Pattern Recognition and Neural Networks, Exam 0.0 cp
- 521497S-02 Pattern Recognition and Neural Networks; Exercise Work 0.0 cp
- 521497S Pattern Recognition and Neural Networks 5.0 cp

**ECTS Credits:**

5 ECTS cr

**Language of instruction:**

English. Examination can be taken in English or Finnish.

**Timing:**

The course unit is held in the spring semester, during period III. It is recommended to complete the
course at the end of studies.

**Learning outcomes:**

After completing the course, student
1. can design simple optimal classifiers from the basic theory and assess their performance.

2. can explain the Bayesian decision theory and apply it to derive minimum error classifiers and minimum cost classifiers.

3. can apply the basics of gradient search method to design a linear discriminant function.

4. can apply regression techniques to practical machine learning problems.

Contents:
Introduction, Bayesian decision theory, Discriminant functions, Parametric and non-parametric classification, Feature extraction, Classifier design, Example classifiers, Statistical regression methods.

Mode of delivery:
Face-to-face teaching, guided laboratory work and independent assignment.

Learning activities and teaching methods:
Lectures 16 h, Laboratory work 16 h, Exercise 16 h and Self-study the rest (Independent task assignment, written examination).

Target group:
Students who are interested in data analysis technology. Students of the University of Oulu.

Prerequisites and co-requisites:
The mathematic studies of the candidate degree program of computer science and engineering, or equivalent. Programming skills, especially basics of the Matlab.

Recommended optional programme components:
The course is an independent entity and does not require additional studies carried out at the same time.

Recommended or required reading:

Assessment methods and criteria:
Laboratory work is supervised by assistants who also check that the task assignments are completed properly. The independent task assignment is graded. The course ends with a written exam. Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course unit utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail. The final grade is established by weighing the written exam by 2/3 and the task assignment by 1/3.

Person responsible:
Tapio Seppänen

Working life cooperation:
No

521279S: Signal Processing Systems, 5 cp

Validity: 01.08.2012 -
Form of study: Advanced Studies
Type: Course
Unit: Computer Science and Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Pekka Sangi
Opintokohteen kielet (E): Finnish

ECTS Credits:
5 ECTS cr

**Language of instruction:**
English

**Timing:**
Autumn, period 2

**Learning outcomes:**
1. Student can explain the challenges of signal processing hardware, software, and design methodologies.
2. Student is able to transform a digital filter designed with floating point arithmetic into a fixed point precision implementation, optimizing the word lengths to achieve the performance specifications.
3. Student is able to explain the most important algorithm implementation structures and can identify their usage contexts.
4. Student has rudimentary practical skills in modeling, designing, and judging finite word length signal processing algorithms with Matlab and Simulink software tools.

**Contents:**
Binary and floating point arithmetic, DSP programming models and co-design, digital signal processors, algorithms and implementations, including CORDIC, transforms (FFT and DCT), multi-rate signal processing, polyphase filters, filter banks, adaptive algorithms and applications. The software environments of the course are Matlab with the Fixed Point Toolbox extension and Simulink with the DSP Blockset extension.

**Mode of delivery:**
Lectures, independent work, group work.

**Learning activities and teaching methods:**
The course consists of lectures (30 h) and design exercises (6-12 h), the rest as independent work (33 h).

**Target group:**
Computer Science and Engineering students: This is an advanced-level course intended for masters-level students, especially to those that are specializing into signal processing. + Other Students of the University of Oulu.

**Prerequisites and co-requisites:**
521337A Digital Filters, 521267A Computer Engineering or 521286A Computer Systems, 8 ECTS cr or 521287A Introduction to Computer Systems, 5 ECTS cr

**Recommended optional programme components:**
The course is an independent entity and does not require additional studies carried out at the same time.

**Recommended or required reading:**
Lecture notes and exercise materials. Material is in English.

**Assessment methods and criteria:**
Grading is based on the evaluation of the design exercises, which are done during the course, and exams, which are arranged during the lectures.
Read more about assessment criteria at the University of Oulu webpage.

**Grading:**
The course unit utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

**Person responsible:**
Pekka Sangi

**Working life cooperation:**
None.
521318S: Modern Topics in Telecommunications and Radio Engineering, 3 - 7 cp

**Form of study:** Advanced Studies

**Type:** Course

**Unit:** Electrical Engineering DP

**Grading:** 1 - 5, pass, fail

**Teachers:** Matti Latva-aho, Jari Iinatti

**Opintokohteen kielet (E):** English

**Voidaan suorittaa useasti (E):** Yes

**ECTS Credits:**

3-7

**Language of instruction:**

English

**Timing:**

Fall & Spring, periods 1-4

**Learning outcomes:**

After completing the course the student understand and is able to analyze basic principles of the topic which has been presented in the course. The final outcomes will be defined based on the contents.

Objective: Depending on each year's topic, the course gives either an overview or deepens knowledge of actual topics and applications on radio techniques and telecommunications. The course comprises varying topical subjects, applications, research areas. Depending on the subject, the course may comprise a seminar of essays that practices a student for spontaneously acquiring information, improves readiness for making a master's thesis and readiness for performing in front of an audience.

**Contents:**

Varies yearly based on actual topics in telecommunications and radio engineering.

**Mode of delivery:**

Face-to-face teaching

**Learning activities and teaching methods:**

Lectures and/or exercises and/or design exercise and/or seminars depending on the topic of the year. The start and implementation of the course will be informed separately. The course can be given several times with different contents during the academic year and it can be included into the degree several times.

**Target group:**

1st and 2nd year M.Sc. and WCE students.

**Prerequisites and co-requisites:**

Will be defined based on the contents.

**Recommended optional programme components:**

-

**Recommended or required reading:**

Will be defined in the beginning of the course.

**Assessment methods and criteria:**

Depends on the working methods.

**Grading:**

The course unit utilizes a numerical grading scale 1-5.

Read more about assessment criteria at the University of Oulu webpage.

**Person responsible:**
Working life cooperation:

Other information:

521325S: Communication Signal Processing, 5 cp

Validity: 01.08.2015 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Juntti, Markku Johannes
Opintokohteen kielet (E): English
Leikkaavuudet (E):

521360S  Synchronisation for Digital Receivers  4.0 cp
521360S-01  Exam, Communication Signal Processing II  0.0 cp
521360S-02  Synchronisation for Digital Receivers, exercise work  0.0 cp

ECTS Credits:
5 ECTS cr / 130 hours of work
Language of instruction:
English
Timing:
The course is held bi-annually in the spring semester, during period 4. It is recommended to complete the course at the 1st or 2nd spring semester of the master studies.

Learning outcomes:
Upon completion the student

1. knows the functional structure of communications transceiver and understands the requirements for various wireless systems for the transceiver.
2. knows the architectural and functional design of (all-)digital transceiver with synchronization, channel estimation, encoding/decoding, multiantenna processing and connection establishment.
3. understands the requirements of the current wireless communications standards and related multiplexing and multiple access on transceiver design.
4. can derive digital domain algorithms for separate functionalities and match them to operate together via agreed interfaces.
5. can model the operation of the algorithms and the whole transceiver using Matlab and C other to assess their performance by computer simulations.

Contents:
Wireless transceiver functional split, digital parts and architecture, multirate filtering and filter banks, transceiver digital front-end architecture and design, synchronization and channel estimation, equalization and soft detection, algorithm-architecture co-simulation, multiantenna transceivers.

Mode of delivery:
Face-to-face teaching and e-learning tool usage.

Learning activities and teaching methods:
Face-face-teaching (lectures, exercises and seminar presentations) 30 h, Simulation and design exercises and presentation preparation in groups 80 h, independent work & passed assignment 20 h.
**Target group:**
Electrical, communications and computer science and engineering students.

**Prerequisites and co-requisites:**
The required prerequisite is the completion of the following courses prior to enrolling for the course: 521348S Statistical signal processing I, 521324S Statistical Signal Processing II, 521323S Wireless communications I, 521317S Wireless communications II.

**Recommended optional programme components:**
-

**Recommended or required reading:**
Parts from books:
5. Other literature, lecture notes and material.

**Assessment methods and criteria:**
Completing the design and simulation projects, giving a seminar presentation on those, and a final exam. In the final grade of the course, the weight for the examination is 0.5 and that of project report 0.5.
Read more about assessment criteria at the University of Oulu webpage.

**Grading:**
The course utilizes a numerical grading scale 1-5. In the numerical scale zero (0) stands for a fail.

**Person responsible:**
Markku Juntti

**Working life cooperation:**
The project focuses on timely design problems in wireless industry. Industrial visiting lectures are organized. The project can be done as true industrial design project.

**Other information:**
Course will be given every second year in odd years. Will be held next time in the spring of 2021.

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**521410S: Special Course in Electronic Design, 4 - 7 cp**

**Validity:** 01.08.2006 -

**Form of study:** Advanced Studies

**Type:** Course

**Unit:** Electrical Engineering DP

**Grading:** 1 - 5, pass, fail

**Teachers:** Rahkonen, Timo Erkki

**Opintokohteen kielet (E):** Finnish

**ECTS Credits:**
4-7 ECTS cr, depending on the yearly contents.

**Language of instruction:**
Finnish or English (if there are at least two foreign students).

**Timing:**
Varies, intensive implementation periods 1-4

**Learning outcomes:**
Vary depending on the content.

**Contents:**
The contents will be fixed yearly during the spring semester. It may be related to RFIC design, or non-linear circuit analysis, for example.

**Mode of delivery:**
Classroom

**Learning activities and teaching methods:**
Varies yearly. The course may contain exercises or a design exercise.

**Target group:**
Electrical Engineering MSc students

**Prerequisites and co-requisites:**
Background in circuit theory and analog and RF design.

**Recommended optional programme components:**
-

**Recommended or required reading:**
Depends on the contents.

**Assessment methods and criteria:**
Depends on the implementation. May contain design exercise.
Read more about assessment criteria at the University of Oulu webpage.

**Grading:**
1-5

**Person responsible:**
Prof. Timo Rahkonen

**Working life cooperation:**
-

**Other information:**
-

555285A: Project management, 5 cp

**Validity:** 01.01.2014 -

**Form of study:** Basic Studies

**Type:** Course

**Unit:** Field of Industrial Engineering and Management

**Grading:** 1 - 5, pass, fail

**Teachers:** Kirsi Aaltonen

**Opintokohteen kielet (E):** Finnish

**Leikkaavuudet (E):**

- 555288A Project Management 5.0 cp
- ay555285A Project management (OPEN UNI) 5.0 cp
- 555282A Project Management 4.0 cp
- 555280P Basic Course of Project Management 2.0 cp
ECTS Credits:
5 ECTS credits.

Language of instruction:
Finnish. English material may also be used.

Timing:
Period 2.

Learning outcomes:
Upon completion of the course, the student will be able to:
• describe explain the essential concepts and methods related to project management
• apply project management methods to create a schedule for a project and calculate critical path
• understand essential concepts related to project cost management and able to apply earned value method and three point estimate to manage project costs
• recognises the essential tasks of project risk management

Contents:
Defining project management, project goals and objectives, project phases and project life-cycle management, project planning, organising and scope management, schedule management, cost management, earned value calculation and project risk management, project stakeholder management, project communications management, the role of project manager, new modes of project delivery

Mode of delivery:
The tuition will be implemented as web-based teaching.

Learning activities and teaching methods:
Web-based lectures 16h, self-study 118h

Target group:
Industrial Engineering and Management students and other students taking Industrial Engineering and Management as minor.

Prerequisites and co-requisites:
No prerequisites exist.

Recommended optional programme components:
This course is part of the 25 ECTS module of Industrial engineering and management that also includes 555225P Basics of industrial engineering and management, 555242A Product development, 555264P Managing well-being and quality of working life, and 555286A Process and quality management.

Recommended or required reading:
Lecture material, exercise book, Artto, Martinsuo & Kujala 2006. Projektiliiketoiminta. WSOY

Assessment methods and criteria:
Assignments, exercise book and exam. The course grading is based on the exam. Well completed assignments and exercise book may raise grading.

Grading:
The course utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.
Person responsible:
Assistant professor Kirsi Aaltonen

Working life cooperation:
The course includes guest lectures from industry

Other information:
Substitutes courses 555280P Basic Course of Project Management + 555282A Project Management.

555391S: Advanced Course in Project Management, 5 cp

Validity: 01.08.2015 -
Form of study: Advanced Studies
Type: Course
Unit: Field of Industrial Engineering and Management
Grading: 1 - 5, pass, fail
Teachers: Kirsi Aaltonen
Opintokohteen kielet (E): English
Leikkaavuudet (E):
   555381S Project Leadership 5.0 cp

ECTS Credits:
5 ECTS credits.

Language of instruction:
English.

Timing:
Periods 1-2.

Learning outcomes:
Upon completion of the course, the student will be able to:
- explain and describe the most important project management areas and tools
- identify and evaluate the most applicable managerial approaches for different types of projects
- identify development needs and opportunities in project-based organisations
- to develop project management processes in an organisation

Contents:
different type of projects and industry specific approaches to project management, agile project management, managing large international projects, project governance, project risk and uncertainty management, project time and schedule management, management of innovative projects.

Mode of delivery:
The tuition will be implemented as blended teaching (web-based teaching and face-to-face teaching).

Learning activities and teaching methods:
Lectures, web-based-lectures and workshops 26h, group exercises and cases 66h, self-study 42h.
Target group:
Industrial Engineering and Management students.

Prerequisites and co-requisites:
555285A Basic course in project management.

Recommended optional programme components:

Recommended or required reading:
Lecture materials and reading materials (articles, book chapters) related to each lecture.

Assessment methods and criteria:
This course utilises continuous assessment. The grading is based on case assignments solved in groups and discussed during the lecture, and group assignment that is presented and discussed in the workshops. Since the implementation of the cases and group work vary, the assessment methods and criteria will be defined at the beginning of the course.

Grading:
The course utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible:
Assistant professor Kirsi Aaltonen

Working life cooperation:
The course includes guest lectures from industry.

Other information:
Substitutes course 555381S Project Leadership.

H451227: Module of the Option, Photonics and Measurement Technology, 60 - 80 cp

Validity: 01.08.2011 -
Form of study: Other Entity
Type: Study module
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Opintokohteen kielet (E): Finnish

No course descriptions.

Module of the option, compulsory studies, 31 ECTS cr

A451223: Module of the Option, Photonics and Measurement Techniques, 30 - 41 cp

Validity: 01.08.2005 -
Form of study: Module of the Option
Type: Study module
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Opintokohteen kielet (E): Finnish
Compulsory courses, 31 ECTS cr

521089S: Printed Electronics, 5 cp

Validity: 01.08.2015 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Tapio Fabritius
Opintokohteen kielet (E): Finnish
Leikkaavuudet (E):
- 521217S Printed Electronics 4.0 cp
- 521095S Advanced Course of Printed Electronics 3.0 cp

ECTS Credits:
5

Language of instruction:
Finnish. English if more than two international students in the course.

Timing:
Period 3.

Learning outcomes:
1. Knows the most typical materials and printing methods suitable for their processing
2. Can explain the principles of materials and printing methods
3. Can utilize the material and manufacturing process knowledge to design fabrication processes for electrical components
4. Can analyse how the selected materials and printing methods influence on the performance of electrical components

Contents:
Materials (conductive and semi-conductive polymers, photoactive polymers, dielectrics, particle based inks) and processing methods (screen printing, gravure printing, flexo printing, inkjet) utilized in printed electronics, surface wetting and film formation, printed electrical components (passive components, solar cells, light emitting diodes, transistors) and their fabrication. Possibilities and challenges of printing based processing methods and how to take them into account in the printed electronics fabrication.

Mode of delivery:
Face-to-face teaching.

Learning activities and teaching methods:
Combined lectures and exercises 30 h and self-study 100 h

Target group:
Primarily for the students of electrical engineering

Prerequisites and co-requisites:
None.

Recommended optional programme components:
The course is an independent entity and does not require additional studies carried out at the same time.
Recommended or required reading:
D.R. Gamota, P. Brazis, K. Kalyanasundaram and J. Zhang, "Printed organic and molecular electronics", handout

Assessment methods and criteria:
Course is completed by final examination.

Grading:
The course unit utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible:
Tapio Fabritius

Working life cooperation:
Not included.

521096S: Measuring Systems, 5 cp

Validity: 01.08.2015 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Juha Saarela
Opintokohteen kielet (E): Finnish
Leikkaavuudet (E):
   521110S  Measuring and Testing Systems  6.0 cp
   521110S-01 Measuring and Testing Systems, exam  0.0 cp
   521110S-02 Measuring and Testing Systems, exercise work  0.0 cp

ECTS Credits:
5 ECTS credits / 128h

Language of instruction:
Finnish. English, if there are more than 2 foreign students.

Timing:
Guided course is on period 2. The course can be completed independently in during spring semester. Ask responsible person for instructions.

Learning outcomes:
1. is able to design a multisensor measurement systems which store the measurement data.
2. is able to assembly a multisensor measurement systems which store the measurement data.
3. is able to program with LabView.

Contents:
Basics of measurement and testing systems, especially wired and wireless data transmission. Data acquisition cards. Basics of LabView programming.

Mode of delivery:
The course can be completed independently during spring semester. Ask instructions from responsible person.

Learning activities and teaching methods:
The course includes 28h lectures and guided exercises. 100 h self-studies.

Target group:
Master level students regardless of master's programme.

**Prerequisites and co-requisites:**
None.

**Recommended optional programme components:**
This course compensates earlier courses with same core content but different course code or credit named Measuring and Testing Systems.

**Recommended or required reading:**
Course material is in English and Finnish and can be found in Optima.

**Assessment methods and criteria:**
Final exam and passed laboratory works.
Read more about assessment criteria at the University of Oulu webpage.

**Grading:**
Grade is based on exam and grade is on numerical scale 1-5.

**Person responsible:**
Juha Saarela

**Working life cooperation:**
No.

521401S: Electronics Design II, 6 cp

**Validity:** 01.08.2017 -
**Form of study:** Advanced Studies

**Type:** Course

**Unit:** Electrical Engineering DP

**Grading:** 1 - 5, pass, fail

**Teachers:** Ilkka Nissinen, Jan Nissinen

**Opintokohteen kielet (E):** English

**ECTS Credits:**
6 ECTS

**Language of instruction:**
In Finnish (In English if needed).

**Timing:**
Autumn, period 1

**Learning outcomes:**
Student
1. should be able to explain the structures and operating principles of the passive and active (BJT and MOS) components available for use in modern IC technologies
2. should be able to analyze and design integrated electronic blocks based on these components, such as operational amplifiers, comparators and sampling circuits
3. should be able to estimate and minimize the effects of noise in electrical circuits
4. should be able to explain the terminology used with DA and AD conversion and converters
5. should be able to analyze and outline the main architectural principles and also to evaluate the characteristics of DA and AD converters

**Contents:**
Modeling of BJT and MOS transistors, CMOS and BJT building blocks especially as IC-realizations, noise and analysis of noise, internal structure of operational amplifiers, critical parameters, comparators, S/H-circuits, structures and properties of A/D and D/A converters.
Mode of delivery:
Face-to-face teaching

Learning activities and teaching methods:
Face-to-face teaching: Lectures 30h, exercises 20h. Self study: a small design work 30h. Learning without guidance either privately or in a group 80h.

Target group:
Students of Electrical engineering. Other students of the University of Oulu may also participate.

Prerequisites and co-requisites:
Principles of electronics design, Electronics design I

Recommended optional programme components:
-

Recommended or required reading:

Assessment methods and criteria:
The course unit is passed by a final exam or by a two midterm exams and a passed design work. Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course unit utilizes a numerical grading scale 1-5.

Person responsible:
Ilkka Nissinen

Working life cooperation:
No

Other information:
-

521088S: Optoelectronics, 5 cp

Validity: 01.01.2014 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Juha Kostamovaara
Opintokohteen kielet (E): Finnish

ECTS Credits:
5
Language of instruction:
Finnish
Timing:
Autumn, period 1
Learning outcomes:
1. is able to explain the principles of operation of optical fibres and waveguides
2. is able to explain the principles of operation of semiconductor light sources and photo
detectors, and knows the factors affecting their performance

3. is able to outline the circuit-level structures for optical transmitter circuits and photo detector preamplifiers

4. is able to compare their performance in terms of the main performance parameters

**Contents:**

**Mode of delivery:**
Face-to-face teaching

**Learning activities and teaching methods:**
Lectures 30 h and exercises 20 h, may include a seminar.

**Target group:**
This course is targeted mainly for the students of electrical engineering degree program, but available for other students as well.

**Prerequisites and co-requisites:**
Principles of semiconductor devices.

**Recommended optional programme components:**
This course is independent, no other components are recommended simultaneously.

**Recommended or required reading:**

**Assessment methods and criteria:**
Final exam.
Read more about [assessment criteria](#) at the University of Oulu webpage.

**Grading:**
Numerical grading scale 1-5.

**Person responsible:**
Juha Kostamovaara

**Working life cooperation:**
Does not apply.

**Other information:**
-

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**521124S: Sensors and Measuring Techniques, 5 cp**

**Form of study:** Advanced Studies

**Type:** Course

**Unit:** Electrical Engineering DP

**Grading:** 1 - 5, pass, fail

**Teachers:** Alexey Popov, Aliaksandr Bykau

**Opintokohteen kielet (E):** Finnish

**ECTS Credits:**
5

**Language of instruction:**
Timing:
Period 2.

Learning outcomes:
After the course the student is capable to explain the operating principles of different sensors and can select a right sensor for each measuring target. He/she is able to quantify the requirements that affect sensor selection as well as recognize and evaluate the uncertainty of a measurement. In addition the student is able to plan and design sensor signal conditioning circuits.

Contents:
Methods for measuring displacement, velocity, acceleration, torque, liquid level, pressure, flow, humidity, sound and temperature. Ultrasound, optical and nuclear measurement techniques and applications, material analyses such as pH measurement and gas concentration, pulp and paper measurements and smart sensors.

Mode of delivery:
Pure face-to-face teaching.

Learning activities and teaching methods:
Lectures 26h, exercises 12h and self-study 100h.

Target group:
4 year students.

Prerequisites and co-requisites:
No.

Recommended optional programme components:
No.

Recommended or required reading:

Assessment methods and criteria:
The course is passed by a final exam and passed exercises. Read more about assessment criteria at the University of Oulu webpage.

Grading:
1-5

Person responsible:
Aliaksandr Bykau ja Alexey Popov

Working life cooperation:
No.
ECTS Credits:
5 ECTS credits / 128h

Language of instruction:
In Finnish or in English if two or more foreign students participate.

Timing:
Period 3.

Learning outcomes:
1. can tell and justifying argument the benefits and challenges of using wireless measurement solutions
2. can apply the most important standards when designing wireless measurement solutions
3. can apply wireless technologies in industrial, traffic, environmental, home and healthcare measurements

Contents:
Basics of wireless measurement technologies and standards, wireless sensors and sensor networks, wireless building and smart home applications, wireless measurement applications in traffic, wireless environmental measurements and wireless human health monitoring.

Mode of delivery:
Face-to-face teaching.

Learning activities and teaching methods:
Lectures 22h. Seminars 6-12h depending on the number of students participating the course. The students prepare seminar presentations about contemporary topics selected by themselves or proposed by the teacher and give 10 minutes presentation to other students in the seminars.

Target group:
Master level students regardless of master's programme.

Prerequisites and co-requisites:
No prerequisites, but basics of measurements systems are recommended.

Recommended optional programme components:
The course replaces previous courses with same name, but different credits and code.

Recommended or required reading:
Lecture notes and seminar reports is Optima.

Assessment methods and criteria:
The course is passed with a written final exam (70 %) and a contemporary seminar (30 %). Read more about assessment criteria at the University of Oulu webpage.

Grading:
Grade is on numerical scale 1-5.

Person responsible:
Juha Saarela

Working life cooperation:
No.
Advanced module, Compulsory Studies 15 ECTS cr (Choose)

521242A: Introduction to Biomedical Engineering, 5 cp

Validity: 01.08.2017 -
Form of study: Intermediate Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Teemu Myllylä
Opintokohteen kielet (E): English

ECTS Credits:
5 ECTS cr
Language of instruction:
English
Timing:
Period 1
Learning outcomes:
After completing the course, the student has a basic knowledge of the biomedical engineering discipline and the applications of engineering science to biomedical problems.

Contents:
Biomedical engineering is a multidisciplinary field of study that ranges from theory to applications at the interface between engineering, medicine and biology. This course will introduce the subdisciplines within biomedical engineering, including such as systems physiology, bioinstrumentation, bioimaging, biophotonics and biomedical signal analysis. General issues of the subdisciplines will be presented together with selected examples and clinical applications. A number of lectures will be given by professionals working in health tech companies, University of Oulu and Oulu University Hospital, presenting different fields of the biomedical engineering. In addition, course offerings of biomedical engineering at the University of Oulu are introduced.

Mode of delivery:
Face-to-face teaching. Under some circumstances distance learning using online material is possible (please, ask the teacher).

Learning activities and teaching methods:
The course includes online material, lectures and a group project. Lectures 28h and laboratory exercises 4 h and self-study 100h

Target group:
Prerequisites and co-requisites:
-
Recommended optional programme components:
-
Recommended or required reading:
-
Assessment methods and criteria:
Participation in lectures or using the online material and writing a work report. Read more about assessment criteria at the University of Oulu webpage.

Grading:
1 - 5, pass, fail

Person responsible:
Teemu Myllylä

Working life cooperation:
Guest lecturers

Other information:
-

521240S: Biophotonics and Biomedical Optics, 5 cp

Validity: 01.08.2015 -

Form of study: Advanced Studies

Type: Course

Unit: Electrical Engineering DP

Grading: 1 - 5, pass, fail

Teachers: Aliaksandr Bykau, Alexey Popov

Opintokohteen kielet (E): Finnish

ECTS Credits:
5

Language of instruction:
English

Timing:
Period 2

Learning outcomes:
On successful completion of the course, students will be able to categorize the basic principles of modern optical and laser-based diagnostic modalities and instruments used in advanced biomedical research and clinical medicine. They will be able to demonstrate detailed understanding and evaluate the key biophotonics techniques underlying day-to-day clinical diagnostic and therapies and industrial applications in pharmacy, health care and cosmetic products. They can operate with the selected techniques of their choice.

Contents:
The course includes in-depth coverage of state-of-the-art optical imaging and spectroscopy systems for advanced biomedical research and clinical diagnosis, fundamental properties of light such as coherence, polarization, angular momentum, details of light interaction with tissue, and modern imaging system. Coherent Optical Tomography (OCT), Laser Doppler Flowmetry, Laser Speckle Imaging (LSI), Photo-Acoustic Tomography (PAT), Tissue polarimetry; Optical and Near-Infra-Red Spectroscopy (NIRS), Confocal and Fluorescence Microscopies; Tissue Optics: Light
Matter interactions, index of refraction, reflection, optical clearing, absorption, Mie scattering, Rayleigh scattering, Monte Carlo modelling.

Mode of delivery:
Face-to-face teaching.

Learning activities and teaching methods:
Lectures/exercises 42 h and self-study 100 h.

Target group:
Students interested in biomedical measurements.

Prerequisites and co-requisites:
None.

Recommended optional programme components:
A new course

Recommended or required reading:

Assessment methods and criteria:
The course is passed by the final exam and with the assignments. Read more about assessment criteria at the University of Oulu webpage.

Grading:
1 - 5

Person responsible:
Aliaksandr Bykau and Alexey Popov

Working life cooperation:
No.

521093S: Biomedical Instrumentation, 5 cp

Validity: 01.08.2015 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Teemu Myllylä
Opintokohteen kielet (E): Finnish
Leikkaavuudet (E):

521107S Biomedical Instrumentation 6.0 cp

ECTS Credits:
5
Language of instruction:
English.
Timing:
Period 4.

Learning outcomes:
After the course the student is capable to explain principles, applications and design of medical instruments most commonly used in hospitals. He/she can describe the electrical safety aspects of
medical instruments and can present the physiological effects of electric current on humans. In addition the student is able to explain medical instrumentation development process and the factors affecting it. He/she also recognizes typical measurands and measuring spans and is able to plan and design a biosignal amplifier.

Contents:
Diagnostic instruments (common theories for medical devices, measurement quantities, sensors, amplifiers and registering instruments). Bioelectrical measurements (EKG, EEG, EMG, EOG, ERG), blood pressure and flow meters, respiration studies, measurements in a clinical laboratory, introduction to medical imaging methods and instruments, ear measurements, heart pacing and defibrillators, physical therapy devices, intensive care and operating room devices and electrical safety aspects.

Mode of delivery:
Face-to-face teaching.

Learning activities and teaching methods:
Lectures/exercises 42 h and self-study 100 h.

Target group:
Students interested in biomedical measurements.

Prerequisites and co-requisites:
None

Recommended optional programme components:
Course replaces earlier courses Biomedical measurements and Biomedical instrumentation.

Recommended or required reading:

Assessment methods and criteria:
The course is passed by the final exam or optionally with the assignments/test agreed at the first lecture.
Read more about assessment criteria at the University of Oulu webpage.

Grading:
1 - 5.

Person responsible:
Teemu Myllylä

Working life cooperation:
No.

521094S: Optoelectronic Sensors of Future, 5 cp

Validity: 01.08.2015 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Anssi Mäkynen
Opintokohteen kielet (E): Finnish
Leikkaavuudet (E):
521238S Optoelectronic Measurements 4.0 cp
ECTS Credits: 5
Language of instruction: English
Timing: Period 3

Learning outcomes:
Objective: The goal of this course is to make the student familiar with optical measurement principles, sensors and device configurations used in industrial inspection tasks.

Learning outcomes: Upon completion of the course, the student is able to explain the operating principles of the most common optical measurement methods used in industrial production, name the factors affecting their performance, design certain sensor systems and evaluate the applicability of measurement methods for various measurement tasks. Additionally he is able to independently find information and discover the operating principles of various optical measurements and to condense the collected information into written and verbal report.

Contents:

Mode of delivery: Face-to-face teaching.

Learning activities and teaching methods:
The course includes 42 h lectures or calculation exercises and 100 h self-studies.

Target group: 4th year students

Prerequisites and co-requisites:
Completion of the course 766329A Wave Motion and Optics is recommended.

Recommended optional programme components:
Course replaces earlier by same name but different code and credit points.

Recommended or required reading:
Lecture handouts and discourse material prepared by students. Delivery through Optima.

Assessment methods and criteria:
Final exam and a passed discourse. Read more about assessment criteria at the University of Oulu webpage.

Grading:
Numerical grading scale 1-5.

Person responsible:
Anssi Mäkynen

Working life cooperation:
No.

A451293: Advanced Module, Testing Techniques and Printed Electronics, 10 - 57 cp

Validity: 01.08.2015 -
Form of study: Advanced Module
Type: Study module
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Opintokohteen kielet (E): Finnish

No course descriptions.

Compulsory studies 15 ECTS cr

521115S: EMC Design, 5 cp

Validity: 01.08.2005 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Hannu Sorvoja
Opintokohteen kielet (E): Finnish

Leikkaavuudet (E):

- 521172S EMC Design 4.0 cp
- 521172S-02 EMC Design, Exercise work 0.0 cp
- 521172S-01 EMC Design, Exam 0.0 cp

ECTS Credits:
5

Language of instruction:
Finnish. English, if there are more than 2 foreign students.

Timing:
Period 4.

Learning outcomes:
1. is able to name common EMC standards
2. is able to use EMC testing equipment and methods
3. can explain the noise coupling mechanisms
4. is able to use good design practices related to analogue and digital electronics design
5. is able to use good design practices related to analogue and digital electronics grounding
6. is able to use good design practices related to analogue and digital electronics filtering
7. is able to use good design practices related to analogue and digital electronics shielding

Contents:
EMC standards for emission and susceptibility, interference coupling, circuit design and grounding, connections, filtering, shielding, EMC testing laboratories, EMC tests and their background.

Mode of delivery:
face-to-face teaching

Learning activities and teaching methods:
The course includes 30 h lectures and 100 h self-studies.
Target group:
Primarily students studying electrical engineering. In addition, other students studying in the University of Oulu can carry out the course.

Prerequisites and co-requisites:
The recommended prerequisite is the completion of the following courses prior to enrolling for the course unit: Electronics Design I, Digital Techniques I, Electronic Measurement Techniques, Measuring and Testing Systems, RF Components and Measurements.

Recommended optional programme components:
The course replaces previous courses with same name, but different credits and code.

Recommended or required reading:

Assessment methods and criteria:
Final exam.
Read more about assessment criteria at the University of Oulu webpage.

Grading:
Grade is based on exam and grade is on numerical scale 1-5.

Person responsible:
Hannu Sorvoja

Working life cooperation:
Company visits if possible.

Other information:
-

521098S: Testing Techniques of Electronics and Printed Electronics, 5 cp

Validity: 01.08.2015 -

Form of study: Advanced Studies

Type: Course

Unit: Electrical Engineering DP

Grading: 1 - 5, pass, fail

Teachers: Tapio Fabritius

Opintokohteen kielet (E): Finnish

ECTS Credits: 5

Language of instruction:
Finnish. English, if there are more than 2 foreign students.

Timing:
Period 4.

Learning outcomes:
1. After completing the course the student is able to analyze different kinds of testing strategies, and is able to enhance the testability of electronics through the use of design for testability.
2. The student can also compare different testing techniques of analogue and digital electronics, which have been implemented using either embedded testing methods or external automatic testing equipment.
3. Additionally, the student is able to analyze tests made using an automatic test instrument, compare different test interfaces and data busses, and recognizes principles of design of a high-quality printed test circuit board.

4. The Student understands the specific features of printed electronics having an influence on electronics testing and reliability.

Contents:
Overview of different testing methods, constructions of testers, test fixtures, test signal generation and measurement, mixed-signal test buses, DC- and parametric measurements, dynamic tests, AD/DA converter tests, DSP-based tests, data analysis, embedded testing, design for testability, Boundary scan, test applications.

Mode of delivery:
Face-to-face teaching.

Learning activities and teaching methods:
Lectures 26h/Exercises 14h and self-studying 100 h.

Target group:
Course is compulsory for the Electrical engineering students in the advanced module of Testing techniques and printed electronics.

Prerequisites and co-requisites:
The recommended prerequisite is the completion of the following courses prior to enrolling for the course unit: Electronics Design I, Electronic Measurement Techniques.

Recommended optional programme components:
This course compensates 521098S Testing Techniques of Electronics if the student hasn’t got credits from it.

Recommended or required reading:
M. Burns, G. W. Roberts: An Introduction to Mixed-Signal IC Test and Measurement, Lecture slides. Additional material will be announced at the beginning of the course.

Assessment methods and criteria:
Exam and passed lab exercises.
Read more about assessment criteria at the University of Oulu webpage.

Grading:
Grade is based on exam and grade is on numerical scale 1-5.

Person responsible:
Tapio Fabritius

Working life cooperation:
No.

521079S: Introduction to Nanotechnology, 5 cp

Validity: 01.08.2015 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Krisztian Kordas
Opintokohteen kielet (E): Finnish
ECTS Credits: 5

Language of instruction: English

Timing: 4th period

Learning outcomes:
1. The students will acquire the basic principles of nanoscience and technology.

2. The course will also help understanding and rational thinking concerning strategies towards practical synthesis and safe utilization of nanomaterials.

Contents:

Mode of delivery:
Lectures

Learning activities and teaching methods:
Though the course is primarily based on lectures, the communication channel is open in both directions enabling continuous comments, questions and feedback from the students. Critical explanations and think alouds are also applied to motivate thinking and active learning.

Target group:
-

Prerequisites and co-requisites:
-

Recommended optional programme components:
-

Recommended or required reading:

Assessment methods and criteria:
Examination.

Grading:
Numerical grading 1-5.

Person responsible:
Krisztian Kordas

Working life cooperation:
-

Other information:
-

Optional Studies (41 ECTS cr): Photonics and measurement techniques. You must take the optional studies to make total 120 ECTS cr

521318S: Modern Topics in Telecommunications and Radio Engineering, 3 - 7 cp
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Matti Latva-aho, Jari Iinatti
Opintokohteen kielet (E): English
Voidaan suorittaa useasti (E): Yes

ECTS Credits:
3-7

Language of instruction:
English

Timing:
Fall&Spring, periods 1-4

Learning outcomes:
After completing the course the student understand and is able to analyze basic principles of the topic which has been presented in the course. The final outcomes will be defined based on the contents.
Objective: Depending on each year's topic, the course gives either an overview or deepens knowledge of actual topics and applications on radio techniques and telecommunications. The course comprises varying topical subjects, applications, research areas. Depending on the subject, the course may comprise a seminar of essays that practices a student for spontaneously acquiring information, improves readiness for making a master's thesis and readiness for performing in front of an audience.

Contents:
Varies yearly based on actual topics in telecommunications and radio engineering.

Mode of delivery:
Face-to-face teaching

Learning activities and teaching methods:
Lectures and/or exercises and/or design exercise and/or seminars depending on the topic of the year. The start and implementation of the course will be informed separately. The course can be given several times with different contents during the academic year and it can be included into the degree several times.

Target group:
1st and 2nd year M.Sc. and WCE students.

Prerequisites and co-requisites:
Will be defined based on the contents.

Recommended optional programme components:
-

Recommended or required reading:
Will be defined in the beginning of the course.

Assessment methods and criteria:
Depends on the working methods.

Grading:
The course unit utilizes a numerical grading scale 1-5.
Read more about assessment criteria at the University of Oulu webpage.

Person responsible:
Matti Latva-aho, Jari Iinatti
**Working life cooperation:**
- 

**Other information:**
- 

**521395S: Wireless Communications I, 5 cp**

**Validity:** 01.08.2019 -
**Form of study:** Advanced Studies
**Type:** Course
**Unit:** Electrical Engineering DP
**Grading:** 1 - 5, pass, fail
**Teachers:** Timo Kokkonen, Jari Iinatti

**Opintokohteen kielet (E):** English

**Leikkaavuudet (E):**

- 521395S-01 Wireless Communications I, Exam 0.0 cp
- 521395S-02 Wireless Communications I, Exercise 0.0 cp
- 521323S Wireless Communications 2 5.0 cp
- 521323S-02 Wireless Communications I, Exercise 0.0 cp
- 521320S Wireless Communications 2 8.0 cp
- 521320S-01 Intermediate exam or final exam, Wireless Communications 2 0.0 cp
- 521320S-02 Exercisework, Wireless Communications 2 0.0 cp
- 521323S-01 Wireless Communications I, Exam 0.0 cp

**ECTS Credits:**
5

**Language of instruction:**
English

**Timing:**
Fall, period 1

**Learning outcomes:**
Student
1. can analyze the performance of multilevel digital modulation methods in AWGN channel
2. can explain the effect of fading channel on the performance of the modulation method and can analyze the performance
3. recognizes and understand suitable diversity methods for fading channel and related combining methods
4. can understand and explain coding methods for wireless channels
5. recognizes different wideband systems
6. understands the cellular system principle

**Contents:**
Radio channel models, digital modulation and detection methods, carrier and symbol synchronization, performance of digital modulation in AWGN and fading channel, diversity techniques, coding for wireless channel, multicarrier modulation, spread spectrum, cellular systems.

**Mode of delivery:**
Face-to-face teaching

**Learning activities and teaching methods:**
Lectures and exercise (total 40 hours) and the compulsory design work with a simulation program (20 h)

Target group:
1st year WCE students and M.Sc. students (i.e., 4th year in ECE degree programme)

Prerequisites and co-requisites:
521330A Telecommunication Engineering

Recommended optional programme components:
-

Recommended or required reading:

Assessment methods and criteria:
The course is passed with minor exams (only during lecture period) or with final exam; and the accepted design work report. In the final grade of the course, the weight for the examination(s) is 0.6 and that for the design work report 0.4.

Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible:
Jari Iinatti / Timo Kokkonen

Working life cooperation:
No

Other information:
-

521016A: Advanced Practical Training, 3 cp

Validity: 01.08.2005 -
Form of study: Intermediate Studies
Type: Practical training
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Hannu Sorvoja
Opintokohteen kielet (E): Finnish
Leikkaavuudet (E):
521026S Advanced practical training 5.0 cp

ECTS Credits:
3
Language of instruction:
Finnish/English
Timing:
1-4
Learning outcomes:
After advanced practical training the student can describe one possible future job, or another kind of position in an already familiar working environment. The student can identify problems in the working environment and solve them. The student can apply theoretical knowledge acquired in the studies to practical tasks. The student can identify roles of a diploma-engineer in the work place.

Contents:
Training in the research laboratories, development laboratories and process laboratories, among others, of the industry and institutions in the field of their study is recommended to the students. The basic requirement is that the practice must be performed in a job supervised by a person who has taken an engineering degree.
The technical goal of practical training is to give a general insight of the field in which the trainee will work after having taken the degree and to support and to promote theoretical studying. Likewise, the training has to acquaint the trainee with the social points of the industrial production and with industrial safety and has to give a sufficient picture of the technical details of the performing of different work. Furthermore, the training has to give a general idea of the technical and economic organizing, administration and management of a company and its production.

**Mode of delivery:**
Independent work.

**Learning activities and teaching methods:**
The students acquire their training job themselves.

**Target group:**
MSc students.

**Prerequisites and co-requisites:**
-

**Recommended optional programme components:**
-

**Recommended or required reading:**
-

**Assessment methods and criteria:**
Students write a report on the compulsory MSc stage practical training lasting at least two months. This report is reviewed by degree program representatives. More detailed instructions for the report are available on the WWW pages of the degree program. Read more about assessment criteria at the University of Oulu webpage.

**Grading:**
Pass/Fail

**Person responsible:**
Hannu Sorvoja

**Working life cooperation:**
Yes.

**Other information:**
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**521362S: Electonics and Communications Engineering Seminar, 0 cp**

**Form of study:** Advanced Studies

**Type:** Course

**Unit:** Electrical Engineering DP

**Grading:** 1 - 5, pass, fail

**Teachers:** Matti Isohookana

**Opintokohteen kielet (E):** Finnish

**Leikkaavuudet (E):**

521350S  Seminar in Telecommunication and Radio Engineering  1.0 cp

**ECTS Credits:**
0

**Language of instruction:**
English

**Timing:**
Autumn and spring, periods 1-4.

**Learning outcomes:**
1. Student can prepare a presentation of predetermined length of her/his thesis.
2. Student has experience on presenting her/his topic.
3. Student has experience on evaluating other students' presentations.
4. Student has a general view of other completed diploma thesis.

**Contents:**
The content is determined by the diploma work topics and other current research topics.

**Mode of delivery:**
Seminar presentations.

**Learning activities and teaching methods:**
Seminar sessions when necessary during the whole year.

**Target group:**
2nd year M.Sc. (after bachelor degree) and WCE students.

**Prerequisites and co-requisites:**
-

**Recommended optional programme components:**
-

**Recommended or required reading:**
Instructions for preparing a diploma work in the degree program.

**Assessment methods and criteria:**
Course is mandatory for all ECE and WCE students regardless of the year a student has started his/her studies. The student has to prepare a presentation from his/her own Master's thesis topic and present it in a seminar. The length of the presentation with questions and discussion is 30 minutes. Presentations are given in English. Seminars are given during the whole year when necessary. Read more about assessment criteria at the University of Oulu webpage.

**Grading:**
The course unit utilizes grading passed.

**Person responsible:**
Matti Isohookana

**Working life cooperation:**
-

**Other information:**
Objective: Students get practice in preparing and giving an oral presentation. At the same time they learn about current research and development projects going on in the university and in the industry.

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**523991S: Master's Thesis in Electronics Design, 30 cp**

**Form of study:** Advanced Studies

**Type:** Diploma thesis

**Unit:** Electrical Engineering DP

**Grading:** 1 - 5, pass, fail

**Opintokohteen kielet (E):** Finnish

No course descriptions.

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**521011S: Maturity Test for Master's Degree, Electronics and Communications Engineering, 0 cp**

**Form of study:** Advanced Studies

**Type:** Course

**Unit:** Electrical Engineering DP

**Grading:** 1 - 5, pass, fail

**Opintokohteen kielet (E):** Finnish

**Voidaan suoriteta useasti (E):** Yes

**ECTS Credits:**
0; The maturity test is integrated in the MSc Thesis credits (30 ECTS).

**Language of instruction:**
Finnish/Swedish/other

**Timing:**
1-4
Learning outcomes:
After the maturity test, the student has demonstrated that his/her language skills meet the requirements of the work life.

Contents:
The aim of the maturity test is to confirm the student's familiarity of the thesis area as well as his/her command of the domestic language of his/her school education.

Mode of delivery:
The maturity test is written in a controlled event, on a topic provided by the thesis supervisor.

Learning activities and teaching methods:
Written essay, approximately 3 pages.

Target group:
- 

Prerequisites and co-requisites:
The maturity test can be written when the thesis is complete or being finished.

Recommended optional programme components:
- 

Recommended or required reading:
MSc thesis

Assessment methods and criteria:
The maturity test is evaluated and approved by the thesis supervisor

Read more about assessment criteria at the University of Oulu webpage.

Grading:
Pass/fail.

Person responsible:
The thesis supervisor.

Working life cooperation:
- 

Other information:
- 

521362S: Electonics and Communications Engineering Seminar, 0 cp

Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Matti Isohookana

Opintokohteen kielet (E): Finnish
Leikkaavuudet (E):

- 521350S Seminar in Telecommunication and Radio Engineering 1.0 cp

ECTS Credits:
0

Language of instruction:
English

Timing:
Autumn and spring, periods 1-4.

Learning outcomes:
1. Student can prepare a presentation of predetermined length of her/his thesis.
2. Student has experience on presenting her/his topic.
3. Student has experience on evaluating other students' presentations.
4. Student has a general view of other completed diploma thesis.

Contents:
The content is determined by the diploma work topics and other current research topics.

Mode of delivery:
Seminar presentations.
Learning activities and teaching methods:
Seminar sessions when necessary during the whole year.

Target group:
2nd year M.Sc. (after bachelor degree) and WCE students.

Prerequisites and co-requisites:
-

Recommended optional programme components:
-

Recommended or required reading:
Instructions for preparing a diploma work in the degree program.

Assessment methods and criteria:
Course is mandatory for all ECE and WCE students regardless of the year a student has started his/her studies. The student has to prepare a presentation from his/her own Master's thesis topic and present it in a seminar. The length of the presentation with questions and discussion is 30 minutes. Presentations are given in English. Seminars are given during the whole year when necessary. Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course unit utilizes grading passed.

Person responsible:
Matti Isohookana

Working life cooperation:
-

Other information:
Objective: Students get practice in preparing and giving an oral presentation. At the same time they learn about current research and development projects going on in the university and in the industry.

523992S: Master's Thesis in Electronics Materials and Components, 30 cp

Form of study: Advanced Studies
Type: Licenciate thesis
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Opintokohteen kielet (E): Finnish

No course descriptions.

521011S: Maturity Test for Master's Degree, Electronics and Communications Engineering, 0 cp

Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Opintokohteen kielet (E): Finnish
Voidaan suorittaa useasti (E): Yes

ECTS Credits:
0; The maturity test is integrated in the MSc Thesis credits (30 ECTS).

Language of instruction:
Finnish/Swedish/other

Timing:
1-4

Learning outcomes:
After the maturity test, the student has demonstrated that his/her language skills meet the requirements of the work life.
Contents:
The aim of the maturity test is to confirm the student's familiarity of the thesis area as well as his/her command of the domestic language of his/her school education.

Mode of delivery:
The maturity test is written in a controlled event, on a topic provided by the thesis supervisor.

Learning activities and teaching methods:
Written essay, approximately 3 pages.

Target group:

Prerequisites and co-requisites:
The maturity test can be written when the thesis is complete or being finished.

Recommended optional programme components:

Recommended or required reading:
MSc thesis

Assessment methods and criteria:
The maturity test is evaluated and approved by the thesis supervisor

Grading:
Pass/fail.

Person responsible:
Thesis supervisor.

Working life cooperation:

Other information:

521362S: Electonics and Communications Engineering Seminar, 0 cp

Form of study: Advanced Studies

Type: Course

Unit: Electrical Engineering DP

Grading: 1 - 5, pass, fail

Teachers: Matti Isohookana

Opintokohteen kielet (E): Finnish

Leikkaavuudet (E):

521350S Seminar in Telecommunication and Radio Engineering 1.0 cp

ECTS Credits:
0

Language of instruction:
English

Timing:
Autumn and spring, periods 1-4.

Learning outcomes:
1. Student can prepare a presentation of predetermined length of her/his thesis.
2. Student has experience on presenting her/his topic.
3. Student has experience on evaluating other students' presentations.
4. Student has a general view of other completed diploma thesis.

Contents:
The content is determined by the diploma work topics and other current research topics.

Mode of delivery:
Seminar presentations.

Learning activities and teaching methods:
Seminar sessions when necessary during the whole year.

Target group:
2nd year M.Sc. (after bachelor degree) and WCE students.

Prerequisites and co-requisites:

Recommended optional programme components:

- 

Recommended or required reading:
Instructions for preparing a diploma work in the degree program.

Assessment methods and criteria:
Course is mandatory for all ECE and WCE students regardless of the year a student has started his/her studies. The student has to prepare a presentation from his/her own Master's thesis topic and present it in a seminar. The length of the presentation with questions and discussion is 30 minutes. Presentations are given in English. Seminars are given during the whole year when necessary. Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course unit utilizes grading passed.

Person responsible:
Matti Isohookana

Working life cooperation:

- 

Other information:
Objective: Students get practice in preparing and giving an oral presentation. At the same time they learn about current research and development projects going on in the university and in the industry.

521998S: Master's Thesis in Telecommunication Engineering, 30 cp

Form of study: Advanced Studies
Type: Diploma thesis
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Opintokohteen kielet (E): Finnish

No course descriptions.

521011S: Maturity Test for Master's Degree, Electronics and Communications Engineering, 0 cp

Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Opintokohteen kielet (E): Finnish
Voidaan suorittaa useasti (E): Yes

ECTS Credits:
0; The maturity test is integrated in the MSc Thesis credits (30 ECTS).

Language of instruction:
Finnish/Swedish/other

Timing:
1-4

Learning outcomes:
After the maturity test, the student has demonstrated that his/her language skills meet the requirements of the work life.

Contents:
The aim of the maturity test is to confirm the student's familiarity of the thesis area as well as his/her command of the domestic language of his/her school education.
Mode of delivery:
The maturity test is written in a controlled event, on a topic provided by the thesis supervisor.

Learning activities and teaching methods:
Written essay, approximately 3 pages.

Target group:
-

Prerequisites and co-requisites:
The maturity test can be written when the thesis is complete or being finished.

Recommended optional programme components:
-

Recommended or required reading:
MSc thesis

Assessment methods and criteria:
The maturity test is evaluated and approved by the thesis supervisor
Read more about assessment criteria at the University of Oulu webpage.

Grading:
Pass/fail.

Person responsible:
Thesis supervisor.

Working life cooperation:
-

Other information:
-

521362S: Electonics and Communications Engineering Seminar, 0 cp

Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Matti Isohookana
Opintokohteen kielet (E): Finnish
Leikkaavuudet (E):
  521350S Seminar in Telecommunication and Radio Engineering 1.0 cp

ECTS Credits:
0

Language of instruction:
English

Timing:
Autumn and spring, periods 1-4.

Learning outcomes:
1. Student can prepare a presentation of predetermined length of her/his thesis.
2. Student has experience on presenting her/his topic.
3. Student has experience on evaluating other students' presentations.
4. Student has a general view of other completed diploma thesis.

Contents:
The content is determined by the diploma work topics and other current research topics.

Mode of delivery:
Seminar presentations.

Learning activities and teaching methods:
Seminar sessions when necessary during the whole year.

Target group:
2nd year M.Sc. (after bachelor degree) and WCE students.

Prerequisites and co-requisites:
-
Recommended optional programme components:
-
Recommended or required reading:
Instructions for preparing a diploma work in the degree program.

Assessment methods and criteria:
Course is mandatory for all ECE and WCE students regardless of the year a student has started his/her studies. The student has to prepare a presentation from his/her own Master's thesis topic and present it in a seminar. The length of the presentation with questions and discussion is 30 minutes.
Presentations are given in English. Seminars are given during the whole year when necessary.
Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course unit utilizes grading passed.

Person responsible:
Matti Isohookana

Working life cooperation:
-

Other information:
Objective: Students get practice in preparing and giving an oral presentation. At the same time they learn about current research and development projects going on in the university and in the industry.

522991S: Master's Thesis in Radio Engineering, 30 cp

Form of study: Advanced Studies
Type: Diploma thesis
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Opintokohteen kielet (E): Finnish

No course descriptions.

521011S: Maturity Test for Master's Degree, Electronics and Communications Engineering, 0 cp

Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Opintokohteen kielet (E): Finnish
Voidaan suorittaa useasti (E): Yes

ECTS Credits:
0; The maturity test is integrated in the MSc Thesis credits (30 ECTS).
Language of instruction:
Finnish/Swedish/other
Timing:
1-4
Learning outcomes:
After the maturity test, the student has demonstrated that his/her language skills meet the requirements of the work life.
Contents:
The aim of the maturity test is to confirm the student's familiarity of the thesis area as well as his/her command of the domestic language of his/her school education.
Mode of delivery:
The maturity test is written in a controlled event, on a topic provided by the thesis supervisor.
Learning activities and teaching methods:
Written essay, approximately 3 pages.

**Target group:**

- 

**Prerequisites and co-requisites:**
The maturity test can be written when the thesis is complete or being finished.

**Recommended optional programme components:**
- 

**Recommended or required reading:**
MSc thesis

**Assessment methods and criteria:**
The maturity test is evaluated and approved by the thesis supervisor

Read more about [assessment criteria](#) at the University of Oulu webpage.

**Grading:**
Pass/fail.

**Person responsible:**
Thesis supervisor.

**Working life cooperation:**
- 

**Other information:**
- 

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**521362S: Electonics and Communications Engineering Seminar, 0 cp**

**Form of study:** Advanced Studies

**Type:** Course

**Unit:** Electrical Engineering DP

**Grading:** 1 - 5, pass, fail

**Teachers:** Matti Isohookana

**Opintokohde kielet (E):** Finnish

**Leikkaavuudet (E):**
521350S Seminar in Telecommunication and Radio Engineering 1.0 cp

**ECTS Credits:**
0

**Language of instruction:**
English

**Timing:**
Autumn and spring, periods 1-4.

**Learning outcomes:**
1. Student can prepare a presentation of predetermined length of her/his thesis.
2. Student has experience on presenting her/his topic.
3. Student has experience on evaluating other students' presentations.
4. Student has a general view of other completed diploma thesis.

**Contents:**
The content is determined by the diploma work topics and other current research topics.

**Mode of delivery:**
Seminar presentations.

**Learning activities and teaching methods:**
Seminar sessions when necessary during the whole year.

**Target group:**
2nd year M.Sc. (after bachelor degree) and WCE students.

**Prerequisites and co-requisites:**
- 

**Recommended optional programme components:**
- 

**Recommended or required reading:**
Instructions for preparing a diploma work in the degree program.

**Assessment methods and criteria:**
Course is mandatory for all ECE and WCE students regardless of the year a student has started his/her studies. The student has to prepare a presentation from his/her own Master's thesis topic and present it in a seminar. The length of the presentation with questions and discussion is 30 minutes. Presentations are given in English. Seminars are given during the whole year when necessary. Read more about assessment criteria at the University of Oulu webpage.

**Grading:**
The course unit utilizes grading passed.

**Person responsible:**
Matti Isohookana

**Working life cooperation:**

**Other information:**
Objective: Students get practice in preparing and giving an oral presentation. At the same time they learn about current research and development projects going on in the university and in the industry.

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**523993S: Master's Thesis in Photonics and Measurement Technology, 30 cp**

**Form of study:** Advanced Studies

**Type:** Diploma thesis

**Unit:** Electrical Engineering DP

**Grading:** 1 - 5, pass, fail

**Opintokohteen kielet (E):** Finnish

No course descriptions.

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**521011S: Maturity Test for Master's Degree, Electronics and Communications Engineering, 0 cp**

**Form of study:** Advanced Studies

**Type:** Course

**Unit:** Electrical Engineering DP

**Grading:** 1 - 5, pass, fail

**Opintokohteen kielet (E):** Finnish

**Voidaan suorittaa useasti (E):** Yes

**ECTS Credits:**
0; The maturity test is integrated in the MSc Thesis credits (30 ECTS).

**Language of instruction:**
Finnish/Swedish/other

**Timing:**
1-4

**Learning outcomes:**
After the maturity test, the student has demonstrated that his/her language skills meet the requirements of the work life.

**Contents:**
The aim of the maturity test is to confirm the student's familiarity of the thesis area as well as his/her command of the domestic language of his/her school education.

**Mode of delivery:**
The maturity test is written in a controlled event, on a topic provided by the thesis supervisor.

**Learning activities and teaching methods:**
Written essay, approximately 3 pages.

**Target group:**
Prerequisites and co-requisites:
The maturity test can be written when the thesis is complete or being finished.

Recommended optional programme components:
- 

Recommended or required reading:
MSc thesis

Assessment methods and criteria:
The maturity test is evaluated and approved by the thesis supervisor
Read more about assessment criteria at the University of Oulu webpage.

Grading:
Pass/fail.

Person responsible:
Thesis supervisor.

Working life cooperation:
- 

Other information:
- 

A451225: Module of the Option, Wireless Communications Engineering, 40 - 65 cp

Validity: 01.08.2005 -
Form of study: Module of the Option
Type: Study module
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Opintokohteen kielet (E): Finnish

No course descriptions.

obligatory studies of the RAN stydy option

031051S: Numerical Matrix Analysis, 5 cp

Validity: 01.08.2012 -
Form of study: Advanced Studies
Type: Course
Unit: Applied Mathematics and Computational Mathematics
Grading: 1 - 5, pass, fail
Teachers: Marko Huhtanen
Opintokohteen kielet (E): Finnish

ECTS Credits:
5 ECTS credits / 135 hours of work

Language of instruction:
Finnish or English.
The course can be completed in English by intermediate exams or by a final exam.

Timing:
Fall semester, period 1

Learning outcomes:
After completing the course the student knows the most efficient and numerically stable methods to solve the basic problems in linear algebra. He/she knows the basic matrix factorizations and their approximations. The student has the capability to solve very large and sparse problems with the iterative solutions methods and understands the significance of preconditioning.

Contents:

Mode of delivery:
Face-to-face teaching

Learning activities and teaching methods:
Lectures 28 h / Group work 14 h / Self-study 93 h.

Target group:
-

Prerequisites and co-requisites:
Completion of courses Calculus I and II, a course on Differential Equations and a Course on Linear Algebra and Numerical analysis

Recommended optional programme components:
-

Recommended or required reading:
Material posted on the web-page of the course.

Assessment methods and criteria:
Intermediate exams or a final exam. Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible:
Marko Huhtanen

Working life cooperation:
-

Other information:
-

521348S: Statistical Signal Processing 1, 5 cp

Validity: 01.08.2016 -

Form of study: Advanced Studies

Type: Course

Unit: Electrical Engineering DP

Grading: 1 - 5, pass, fail

Teachers: Janne Lehtomäki, Juntti, Markku Johannes

Opintokohteen kielet (E): Finnish

Leikkaavuudet (E):

521484A Statistical Signal Processing 5.0 cp

ECTS Credits:
5 ECTS
Language of instruction:
English

Timing:
The course is held in the autumn semester, during period 1. It is recommended to complete the course at the 1st semester of the master studies.

Learning outcomes:
Upon completion the student
1. knows the key tools of linear algebra and optimization and can apply them in solving signal processing problems.
2. understands the key concepts in estimation theory such as the classical and Bayesian framework.
3. masters the most important estimation principles such as minimum variance, maximum likelihood, least squares and minimum mean square error estimators.
4. can derive an estimator for a given criterion and basic data models.
5. can use the methodology of estimation theory to analyze the performance of estimators
6. understands the basics of detection and classification theory: hypothesis testing, receiver operating characteristics (ROC), matched filter, estimator-correlator

Contents:
Review of probability, linear algebra, random variables and stochastic processes; SVD (Singular value decomposition), QR decomposition, estimation theory, minimum variance unbiased estimator, Cramer-Rao lower bound, linear models, general minimum variance unbiased estimation, best linear unbiased estimators, maximum likelihood estimation, least squares estimation, Bayesian estimation, linear Bayesian estimation, Wiener filters, statistical decision theory, receiver operating characteristics, hypothesis testing, matched filter, estimator-correlator.

Mode of delivery:
Face-to-face teaching and e-learning tool usage

Learning activities and teaching methods:
Face-to-face-teaching (lectures and exercises) 50h, Matlab simulation exercises in groups 30 h, independent work & passed assignment 50 h.

Target group:
Electrical, communications and computer science and engineering students.

Prerequisites and co-requisites:
The required prerequisite is the completion of the following courses prior to enrolling for the course: 031080A Signal Analysis, 031021P Probability and Mathematical Statistics, 031078P Matrix Algebra, 521330A Telecommunication Engineering.

Recommended optional programme components:
521323S Wireless communications I and 031051S Numerical Matrix Analysis are recommended to be taken in parallel.

Recommended or required reading:
Parts from books:
5. Other literature, lecture notes and material.

Assessment methods and criteria:
Completing the simulation project tasks, and a mid-term exam during the course. The mid-term exams can be retaken by a final exam later. In the final grade of the course, the weight for the examination is 0.7 and that of project report 0.3.
Read more about assessment criteria at the University of Oulu webpage.
Grading:
The course utilizes a numerical grading scale 1-5. In the numerical scale zero (0) stands for a fail.

Person responsible:
Janne Lehtomäki and Markku Juntti

Working life cooperation:
No

Other information:

521395S: Wireless Communications I, 5 cp

Validity: 01.08.2019 - 
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Timo Kokkonen, Jari Iinatti

Opintokohteen kielet (E): English
Leikkaavuudet (E):

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Description</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>521395S-01</td>
<td>Wireless Communications I, Exam</td>
<td>0.0 cp</td>
</tr>
<tr>
<td>521395S-02</td>
<td>Wireless Communications I, Exercise</td>
<td>0.0 cp</td>
</tr>
<tr>
<td>521323S</td>
<td>Wireless Communications 2</td>
<td>5.0 cp</td>
</tr>
<tr>
<td>521323S-02</td>
<td>Wireless Communications I, Exercise</td>
<td>0.0 cp</td>
</tr>
<tr>
<td>521320S</td>
<td>Wireless Communications 2</td>
<td>8.0 cp</td>
</tr>
<tr>
<td>521320S-01</td>
<td>Intermediate exam or final exam, Wireless Communications 2</td>
<td>0.0 cp</td>
</tr>
<tr>
<td>521320S-02</td>
<td>Exercisework, Wireless Communications 2</td>
<td>0.0 cp</td>
</tr>
<tr>
<td>521323S-01</td>
<td>Wireless Communications I, Exam</td>
<td>0.0 cp</td>
</tr>
</tbody>
</table>

ECTS Credits:
5

Language of instruction:
English

Timing:
Fall, period 1

Learning outcomes:
Student
1. can analyze the performance of multilevel digital modulation methods in AWGN channel
2. can explain the effect of fading channel on the performance of the modulation method and can analyze the performance
3. recognizes and understand suitable diversity methods for fading channel and related combining methods
4. can understand and explain coding methods for wireless channels
5. recognizes different wideband systems
6. understands the cellular system principle

Contents:
Radio channel models, digital modulation and detection methods, carrier and symbol synchronization, performance of digital modulation in AWGN and fading channel, diversity techniques, coding for wireless channel, multicarrier modulation, spread spectrum, cellular systems.
Mode of delivery:
Face-to-face teaching

Learning activities and teaching methods:
Lectures and exercise (total 40 hours) and the compulsory design work with a simulation program (20 h)

Target group:
1st year WCE students and M.Sc. students (i.e., 4th year in ECE degree programme)

Prerequisites and co-requisites:
521330A Telecommunication Engineering

Recommended optional programme components:
-

Recommended or required reading:

Assessment methods and criteria:
The course is passed with minor exams (only during lecture period) or with final exam; and the accepted design work report. In the final grade of the course, the weight for the examination(s) is 0.6 and that for the design work report 0.4.

Grading:
The course utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible:
Jari Iinatti / Timo Kokkonen

Working life cooperation:
No

Other information:
-

031025A: Introduction to Optimization, 5 cp

Form of study: Intermediate Studies
Type: Course
Unit: Applied Mathematics and Computational Mathematics
Grading: 1 - 5, pass, fail
Teachers: Ruotsalainen Keijo
Opintokohteen kielet (E): English

ECTS Credits:
5 ECTS credits / 135 hours of work

Language of instruction:
English

Timing:
The course is held in the autumn, during period 1.

Learning outcomes:
After completing the course the student is able to solve optimization convex optimization problems with the basic optimization algorithms. The student is also able to form the necessary and sufficient conditions for the optimality.

Contents:
Linear optimization, Simplex-algorithm, nonlinear optimization, KKT-conditions, duality, conjugate gradient method, penalty and barrier function methods.

**Mode of delivery:**
Face-to-face teaching

**Learning activities and teaching methods:**
Lectures 28 h / Group work 14 h / Self-study 93 h.

**Target group:**
Students in Wireless Communication Engineering

**Prerequisites and co-requisites:**
The recommended prerequisite is the completion of the courses Calculus I and II, Matrix algebra

**Recommended optional programme components:**
-

**Recommended or required reading:**
P. Ciarlet; Introduction to numerical linear algebra and optimization, M. Bazaraa, H. Sherali, C.M. Shetty; Nonlinear programming

**Assessment methods and criteria:**
The course can be completed by a final exam.
Read more about assessment criteria at the University of Oulu webpage.

**Grading:**
The course utilizes a numerical grading scale 0-5. In the numerical scale zero stands for a fail

**Person responsible:**
Keijo Ruotsalainen

**Working life cooperation:**
-

**Other information:**
-

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521340S: Communications Networks I, 5 cp

**Form of study:** Advanced Studies

**Type:** Course

**Unit:** Electrical Engineering DP

**Grading:** 1 - 5, pass, fail

**Teachers:** Mika Ylianttila

**Opintokohteen kielet (E):** English

**ECTS Credits:**
5 ECTS cr

**Language of instruction:**
English

**Timing:**
Fall, period 2

**Learning outcomes:**
1. Students understand how the modern communications networks have evolved and how the architecture has changed through the recent paradigm shift towards software-centric communications.
2. Students are able to describe the basic system architecture elements of mobile networks, and understands the significance of emerging technologies such as Network Function Virtualization (NFV), Software Defined Networking (SDN), and core network functionalities such as Evolved Packet Core (EPC).

3. Students can describe the main principles of mobility management, network management and orchestration, and network security, and can apply and solve related engineering problems.

4. Students know the basic properties of routing algorithms, and can use graph theory to solve network routing problems.

5. Students are able to simulate different types of networks in simulation environments and solve basic network programming problems. Upon completing the required coursework, students understand the basic functionalities in TCP/IP protocol stack.

Contents:
Communications architecture in mobile, wireless local area and personal area networks. Introduction to cloud and edge computing, network function virtualization and software defined networking. Basic principles of mobility management, network security, network management and orchestration. The goal is to present the basics of the modern communications architectures, and their technical implementation.

Mode of delivery:
Face-to-face teaching.

Learning activities and teaching methods:
Lectures 30 h and the compulsory design work (15 h). Design work can be done alternatively either as NS-2 simulation or TCP/IP programming exercise. Design work instructions are provided in digital learning environment (Optima / Moodle).

Target group:
1st year M.Sc. and WCE students

Prerequisites and co-requisites:
-

Recommended optional programme components:
The course is an independent entity and does not require additional studies carried out at the same time.

Recommended or required reading:
Software Defined Mobile Networks (SDMN): Beyond LTE Network Architecture, M Liyanage, A Gurtov, M Ylianttila – 2015; A comprehensive Guide to 5G Security, M Liyanage, I Ahmad, A Abro, A Gurtov, M Ylianttila – 2018; In addition, selected supportive online reading materials from recent standards and publications are provided in digital learning environment (Optima / Moodle).

Assessment methods and criteria:
The course is passed with a final examination and the accepted design work report. The final grade is based on examination.
Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course unit utilizes a numerical grading scale 1-5.

Person responsible:
Mika Ylianttila

Working life cooperation:
No

Other information:
-

521324S: Statistical Signal Processing II, 5 cp

Validity: 01.08.2015 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Juntti, Markku Johannes
Leikkaavuudet (E):

<table>
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<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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<tr>
<td>521373S</td>
<td>Statistical Signal Processing 2</td>
<td>6.0 cp</td>
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<tr>
<td>521373S-01</td>
<td>Statistical Signal Processing 2, exam</td>
<td>0.0 cp</td>
</tr>
<tr>
<td>521373S-02</td>
<td>Statistical Signal Processing 2, exercise work</td>
<td>0.0 cp</td>
</tr>
</tbody>
</table>

ECTS Credits: 5

Language of instruction: English

Timing:
The course is held in the spring semester, during period 3. It is recommended to complete the course at the 1st spring semester of the master studies.

Learning outcomes:
Upon completion the student will
1. understand the key design problems and constraints of the design of typical estimation problems in statistical signal processing.
2. have the skills to apply estimation, detection and other statistical signal processing methods to solve practical problems in communications.
3. can use linear algebra, basics of optimization and statistical signal processing to derive algorithms with statistical models or driven by data.
4. can use numerical analysis to approximate optimal algorithms with iterative solutions including (un)supervised adaptive algorithms.
5. understands the basic requirements for the convergence of an iterative and adaptive algorithm.
6. can model the operation of a transceiver using Matlab and other simulators to assess the performance of transceiver algorithms.

Contents:

Mode of delivery:
Face-to-face teaching and e-learning tool usage

Learning activities and teaching methods:
Face-face-teaching (lectures and exercises) 50h, Matlab simulation exercises in groups 30 h, independent work & passed assignment 50 h.

Target group:
Electrical, communications and computer science and engineering students.

Prerequisites and co-requisites:
The required prerequisite is the completion of the following courses prior to enrolling for the course: 031080A Signal Analysis, 031021P Probability and Mathematical Statistics, 031078P Matrix Algebra, 521330A Telecommunication Engineering, 521348S Statistical Signal Processing I. The recommended prerequisite is the completion of 521323S Wireless Communications I, 031025A Introduction to Optimization and 031051S Numerical Matrix Analysis.

Recommended optional programme components:
521317S Wireless communications II is recommended to be taken in parallel.

**Recommended or required reading:**

Parts from books:

6. Other literature, lecture notes and material.

**Assessment methods and criteria:**

Completing the simulation project tasks, and a mid-term exam during the course. The mid-term exams can be retaken by a final exam later. In the final grade of the course, the weight for the examination is 0.6 and that of project report 0.4.

Read more about [assessment criteria](https://www.oulu.fi) at the University of Oulu webpage.

**Grading:**

The course utilizes a numerical grading scale 1-5. In the numerical scale zero (0) stands for a fail.

**Person responsible:**

Markku Juntti and Janne Lehtomäki

**Working life cooperation:**

No

**Other information:**

-

521349S: Wireless Communications II, 5 cp

**Form of study:** Advanced Studies

**Type:** Course

**Unit:** Electrical Engineering DP

**Grading:** 1 - 5, pass, fail

**Teachers:** Antti-Heikki Tölli

**Opintokohteen kielet (E):** English

**ECTS Credits:**

5

**Language of instruction:**

English

**Timing:**

Spring, periods 3-4

**Learning outcomes:**

1. The student is familiarised with the channel capacity as the fundamental performance measure of wireless communication links, and can explain the effect of fading channel on the capacity in a single-user single-antenna scenarios.
2. The student understands the basic principles for multiuser communications in fading channels, apprehends the notion of capacity region for multi-access and broadcast channels, and is familiarised with different practical multiple access, random access and scheduling methods.
3. The student is acquainted with core principles of adaptive transmission, which requires accurate channel estimates at the receiver and a reliable information exchange mechanisms between the receiver
and transmitter. Practical variable-rate variable-power MQAM modulation techniques for fading channels are introduced.
4. The student understands the principles of transmitter and receiver design in the presence of channel distortion. The student is familiarised with various (adaptive) equalization solutions to combat intersymbol interference.
5. Finally, the student is acquainted with the capacity optimal multi-antenna transmission and reception scheme, as well as, with basic multiantenna space-time coding schemes in a single-user multiple-input multiple-output (MIMO) communications scenario.

Contents:
Capacity of wireless channels, multiuser communications, adaptive modulation and coding, equalization, point-to-point MIMO communications and space-time coding.

Mode of delivery:
Face-to-face teaching

Learning activities and teaching methods:
Lectures and exercise (total 40 hours) and the compulsory design work with a simulation program (20 h).

Target group:
1st year WCE students and M.Sc. students (i.e., 4th year in ECE degree programme).

Prerequisites and co-requisites:
In addition to courses “521395S Wireless Communications I”, 521348S “Statistical Signal Processing I”, 031025A “Introduction to optimization” and 031051S “Numerical matrix analysis”, a working knowledge in digital communications, random processes, linear algebra, matrix manipulation and detection theory is required.

Recommended optional programme components:
Prior knowledge of 521390S Information Theory and 521392S Convex Optimisation is very useful but not mandatory. The course 521324S Statistical Signal Processing II is recommended to be taken in parallel.

Recommended or required reading:

Assessment methods and criteria:
The course is passed with a final examination and the accepted simulation work report. The final grade is a weighted sum of exam (70%), homework (20%), and work report (10%).

Grading:
The course unit utilizes a numerical grading scale 1-5.

Person responsible:
Antti Tölli

Working life cooperation:
No

Other information:
Course replaces the old course 521317S Wireless Communications II (8cr).
Teachers: Aarno Pärssinen, Risto Vuhtoniemi

Opintokohde (E): Finnish

Leikkaavuudet (E):

<table>
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<tr>
<th>Course Code</th>
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<th>Credits</th>
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<td>521326S-01</td>
<td>Radio Engineering</td>
<td>0.0 cp</td>
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<tr>
<td>521326S-02</td>
<td>Exercise work, Radio engineering</td>
<td>0.0 cp</td>
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<tr>
<td>521335S-01</td>
<td>Radio engineering, partial credit</td>
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<tr>
<td>521335S</td>
<td>Radio Engineering</td>
<td>6.0 cp</td>
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</table>

ECTS Credits: 5

Language of instruction: English

Timing: Fall, period 2

Learning outcomes:

1. learns key components of radio transceivers used in wireless communications including LTE and 5G.
2. knows different kind of impedance matching methods and can design the impedance matching network using lumped components and microstrip lines.
   A student can also explain factors, which are limiting the bandwidth of impedance matching networks.
   Smith chart (admittance/impedance chart).
3. will be able to design a low noise RF amplifier. The amplifier is designed that the noise figure is minimized or the gain is maximized. The impedance matching can also be made for the constant gain.
4. knows single sideband and double sideband noise in mixers. A student will be able to design balanced and double balanced mixer and knows the advantages and the disadvantages of these mixers.
5. will be able to design passive microwave components like a Wilkinson power divider, a directional coupler and hybrids.
6. can explain basic principles of RF-oscillators. A student can design a cross-coupled oscillator and voltage controlled oscillator.
7. knows concept of noise, non-linearity and dynamic range as used in radio frequency communications.
8. can classify power amplifiers and will be able in the basic case design the matching network for a power amplifier.

Contents:
Noise, non-linearity, impedance matching using lumped components, microstrip matching networks, low noise amplifier (LNA) design, active and passive mixers design, Wilkinson power dividers, directional couplers, hybrids, automatic gain control (AGC), cross-coupled oscillator, voltage controlled oscillators, power amplifier design.

Mode of delivery:
Face-to-face teaching

Learning activities and teaching methods:
Lectures 24 h, exercises 16 h and the compulsory RF design work with ADS simulation software (20 h).

Target group:
1st year M.Sc. and WCE-RF students. 2nd year M.Sc. (Telecom.) and WCE-RAN students.

Prerequisites and co-requisites:
Basics of Radio Engineering

Recommended optional programme components:
-

Recommended or required reading:
Assessment methods and criteria:
The course is passed with a final examination and the accepted simulation work report. In the final grade of the course, the weight for the examination is 0.75 and that for the simulation work 0.25. Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course unit utilizes a numerical grading scale 1-5.

Person responsible:
Risto Vuohtoniemi, Aarno Pärssinen.

Working life cooperation:
No

Other information:

A451226: Module of the option, RF Engineering, 36 - 71 cp

Validity: 01.08.2017 -
Form of study: Module of the Option
Type: Study module
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Opintokohteen kielet (E): Finnish

No course descriptions.

Obligatory studies: basic and advanced module, tot. 36 ECTS cr

521401S: Electronics Design II, 6 cp

Validity: 01.08.2017 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Ilkka Nissinen, Jan Nissinen
Opintokohteen kielet (E): English

ECTS Credits:
6 ECTS
Language of instruction:
In Finnish (In English if needed).
Timing:
Autumn, period 1
Learning outcomes:
Student
1. should be able to explain the structures and operating principles of the passive and active (BJT and MOS) components available for use in modern IC technologies
2. should be able to analyze and design integrated electronic blocks based on these components, such as operational amplifiers, comparators and sampling circuits
3. should be able to estimate and minimize the effects of noise in electrical circuits
4. should be able to explain the terminology used with DA and AD conversion and converters
5. should be able to analyze and outline the main architectural principles and also to evaluate the characteristics of DA and AD converters

Contents:
Modeling of BJT and MOS transistors, CMOS and BJT building blocks especially as IC-realizations, noise and analysis of noise, internal structure of operational amplifiers, critical parameters, comparators, S/H-circuits, structures and properties of A/D and D/A converters.

Mode of delivery:
Face-to-face teaching

Learning activities and teaching methods:
Face-to-face teaching: Lectures 30h, exercises 20h. Self study: a small design work 30h. Learning without guidance either privately or in a group 80h.

Target group:
Students of Electrical engineering. Other students of the University of Oulu may also participate.

Prerequisites and co-requisites:
Principles of electronics design, Electronics design I

Recommended optional programme components:
-

Recommended or required reading:

Assessment methods and criteria:
The course unit is passed by a final exam or by a two midterm exams and a passed design work. Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course unit utilizes a numerical grading scale 1-5.

Person responsible:
Ilkka Nissinen

Working life cooperation:
No

Other information:
-

521348S: Statistical Signal Processing 1, 5 cp

Validity: 01.08.2016 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Janne Lehtomäki, Juntti, Markku Johannes
Opintokohteen kielet (E): Finnish
Leikkaavuudet (E):

521484A  Statistical Signal Processing  5.0 cp

ECTS Credits:
5 ECTS
Language of instruction:
English

Timing:
The course is held in the autumn semester, during period 1. It is recommended to complete the course at the 1st semester of the master studies.

Learning outcomes:
Upon completion the student
1. knows the key tools of linear algebra and optimization and can apply them in solving signal processing problems.
2. understands the key concepts in estimation theory such as the classical and Bayesian framework.
3. masters the most important estimation principles such as minimum variance, maximum likelihood, least squares and minimum mean square error estimators.
4. can derive an estimator for a given criterion and basic data models.
5. can use the methodology of estimation theory to analyze the performance of estimators
6. understands the basics of detection and classification theory: hypothesis testing, receiver operating characteristics (ROC), matched filter, estimator-correlator

Contents:
Review of probability, linear algebra, random variables and stochastic processes; SVD (Singular value decomposition), QR decomposition, estimation theory, minimum variance unbiased estimator, Cramer-Rao lower bound, linear models, general minimum variance unbiased estimation, best linear unbiased estimators, maximum likelihood estimation, least squares estimation, Bayesian estimation, linear Bayesian estimation, Wiener filters, statistical decision theory, receiver operating characteristics, hypothesis testing, matched filter, estimator-correlator.

Mode of delivery:
Face-to-face teaching and e-learning tool usage

Learning activities and teaching methods:
Face-to-face-teaching (lectures and exercises) 50h, Matlab simulation exercises in groups 30 h, independent work & passed assignment 50 h.

Target group:
Electrical, communications and computer science and engineering students.

Prerequisites and co-requisites:
The required prerequisite is the completion of the following courses prior to enrolling for the course: 031080A Signal Analysis, 031021P Probability and Mathematical Statistics, 031078P Matrix Algebra, 521330A Telecommunication Engineering.

Recommended optional programme components:
521323S Wireless communications I and 031051S Numerical Matrix Analysis are recommended to be taken in parallel.

Recommended or required reading:
Parts from books:
5. Other literature, lecture notes and material.

Assessment methods and criteria:
Completing the simulation project tasks, and a mid-term exam during the course. The mid-term exams can be retaken by a final exam later. In the final grade of the course, the weight for the examination is 0.7 and that of project report 0.3.
Read more about assessment criteria at the University of Oulu webpage.
**Grading:**
The course utilizes a numerical grading scale 1-5. In the numerical scale zero (0) stands for a fail.

**Person responsible:**
Janne Lehtomäki and Markku Juntti

**Working life cooperation:**
No

**Other information:**
-

**521395S: Wireless Communications I, 5 cp**

**Validity:** 01.08.2019 -

**Form of study:** Advanced Studies

**Type:** Course

**Unit:** Electrical Engineering DP

**Grading:** 1 - 5, pass, fail

**Teachers:** Timo Kokkonen, Jari Iinatti

**Opintokohteen kielet (E):** English

**Leikkaavuudet (E):**

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<td>521395S-02</td>
<td>Wireless Communications I, Exercise</td>
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<td>521323S</td>
<td>Wireless Communications 2</td>
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<td>Wireless Communications I, Exercise</td>
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<tr>
<td>521323S-01</td>
<td>Wireless Communications I, Exam</td>
<td>0.0 cp</td>
</tr>
</tbody>
</table>

**ECTS Credits:**

5

**Language of instruction:**
English

**Timing:**
Fall, period 1

**Learning outcomes:**
Student
1. can analyze the performance of multilevel digital modulation methods in AWGN channel
2. can explain the effect of fading channel on the performance of the modulation method and can analyze the performance
3. recognizes and understand suitable diversity methods for fading channel and related combining methods
4. can understand and explain coding methods for wireless channels
5. recognizes different wideband systems
6. understands the cellular system principle

**Contents:**
Radio channel models, digital modulation and detection methods, carrier and symbol synchronization, performance of digital modulation in AWGN and fading channel, diversity techniques, coding for wireless channel, multicarrier modulation, spread spectrum, cellular systems.
Mode of delivery:
Face-to-face teaching

Learning activities and teaching methods:
Lectures and exercise (total 40 hours) and the compulsory design work with a simulation program (20 h)

Target group:
1st year WCE students and M.Sc. students (i.e., 4th year in ECE degree programme)

Prerequisites and co-requisites:
521330A Telecommunication Engineering

Recommended optional programme components:
-

Recommended or required reading:

Assessment methods and criteria:
The course is passed with minor exams (only during lecture period) or with final exam; and the accepted design work report. In the final grade of the course, the weight for the examination(s) is 0.6 and that for the design work report 0.4.
Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible:
Jari Iinatti / Timo Kokkonen

Working life cooperation:
No

Other information:
-

521326S: Radio Engineering 1, 5 cp

Validity: 01.08.2015 -

Form of study: Advanced Studies

Type: Course

Unit: Electrical Engineering DP

Grading: 1 - 5, pass, fail

Teachers: Aarno Pärssinen, Risto Vuohtoniemi

Opintokohteen kielet (E): Finnish

Leikkaavuudet (E):

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<td>Exercise work, Radio engineering</td>
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<td>Radio engineering, partial credit</td>
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<tr>
<td>521335S-02</td>
<td>Radio engineering, partial credit</td>
<td>0.0 cp</td>
</tr>
<tr>
<td>521335S</td>
<td>Radio Engineering</td>
<td>6.0 cp</td>
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</table>

ECTS Credits:
5

Language of instruction:
English
Timing:
Fall, period 2

Learning outcomes:
1. learns key components of radio transceivers used in wireless communications including LTE and 5G.
2. knows different kind of impedance matching methods and can design the impedance matching network using lumped components and microstrip lines.
A student can also explain factors, which are limiting the bandwidth of impedance matching networks. Smith chart (admittance/impedance chart).
3. will be able to design a low noise RF amplifier. The amplifier is designed that the noise figure is minimized or the gain is maximized. The impedance matching can also be made for the constant gain.
4. knows single sideband and double sideband noise in mixers. A student will be able to design balanced and double balanced mixer and knows the advantages and the disadvantages of these mixers.
5. will be able to design passive microwave components like a Wilkinson power divider, a directional coupler and hybrids.
6. can explain basic principles of RF-oscillators. A student can design a cross-coupled oscillator and voltage controlled oscillator.
7. knows concept of noise, non-linearity and dynamic range as used in radio frequency communications.
8. can classify power amplifiers and will be able in the basic case design the matching network for a power amplifier.

Contents:
Noise, non-linearity, impedance matching using lumped components, microstrip matching networks, low noise amplifier (LNA) design, active and passive mixers design, Wilkinson power dividers, directional couplers, hybrids, automatic gain control (AGC), cross-coupled oscillator, voltage controlled oscillators, power amplifier design.

Mode of delivery:
Face-to-face teaching

Learning activities and teaching methods:
Lectures 24 h, exercises 16 h and the compulsory RF design work with ADS simulation software (20 h).

Target group:
1st year M.Sc. and WCE-RF students. 2nd year M.Sc. (Telecom.) and WCE-RAN students.

Prerequisites and co-requisites:
Basics of Radio Engineering

Recommended optional programme components:
-

Recommended or required reading:

Assessment methods and criteria:
The course is passed with a final examination and the accepted simulation work report. In the final grade of the course, the weight for the examination is 0.75 and that for the simulation work 0.25.
Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course unit utilizes a numerical grading scale 1-5.

Person responsible:
Risto Vuohtoniemi, Aarno Pärssinen.

Working life cooperation:
No

Other information:
-
521324S: Statistical Signal Processing II, 5 cp

Validity: 01.08.2015 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Juntti, Markku Johannes

Opintokohteen kielet (E): English
Leikkaavuudet (E):

- 521373S Statistical Signal Processing 2 6.0 cp
- 521373S-01 Statistical Signal Processing 2, exam 0.0 cp
- 521373S-02 Statistical Signal Processing 2, exercise work 0.0 cp

ECTS Credits:
5

Language of instruction:
English

Timing:
The course is held in the spring semester, during period 3. It is recommended to complete the course at the 1st spring semester of the master studies.

Learning outcomes:
Upon completion the student will
1. understand the key design problems and constraints of the design of typical estimation problems in statistical signal processing.
2. have the skills to apply estimation, detection and other statistical signal processing methods to solve practical problems in communications.
3. can use linear algebra, basics of optimization and statistical signal processing to derive algorithms with statistical models or driven by data.
4. can use numerical analysis to approximate optimal algorithms with iterative solutions including (un)supervised adaptive algorithms.
5. understands the basic requirements for the convergence of an iterative and adaptive algorithm.
6. can model the operation of a transceiver using Matlab and other simulators to assess the performance of transceiver algorithms.

Contents:

Mode of delivery:
Face-to-face teaching and e-learning tool usage

Learning activities and teaching methods:
Face-face-teaching (lectures and exercises) 50h, Matlab simulation exercises in groups 30 h, independent work & passed assignment 50 h.

Target group:
Electrical, communications and computer science and engineering students.

Prerequisites and co-requisites:
The required prerequisite is the completion of the following courses prior to enrolling for the course: 031080A Signal Analysis, 031021P Probability and Mathematical Statistics, 031078P Matrix Algebra,
521330A Telecommunication Engineering, 521348S Statistical Signal Processing I. The recommended prerequisite is the completion of 521323S Wireless Communications I, 031025A Introduction to Optimization and 031051S Numerical Matrix Analysis.

Recommended optional programme components:
521317S Wireless communications II is recommended to be taken in parallel.

Recommended or required reading:
Parts from books:

6. Other literature, lecture notes and material.

Assessment methods and criteria:
Completing the simulation project tasks, and a mid-term exam during the course. The mid-term exams can be retaken by a final exam later. In the final grade of the course, the weight for the examination is 0.6 and that of project report 0.4.

Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course utilizes a numerical grading scale 1-5. In the numerical scale zero (0) stands for a fail.

Person responsible:
Markku Juntti and Janne Lehtomäki

Working life cooperation:
No

Other information:

521225S: RF Components and Measurements, 5 cp

Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Teirikangas, Merja Elina
Opintokohteen kielet (E): Finnish

ECTS Credits:
5 ECTS credits / 132,5 hours of work

Language of instruction:
Finnish. English, if there are at least 3 international students in class.

Timing:
The course is held in the 4th period. It is recommended to complete the course during Master level studies.

Learning outcomes:
1. After completing the course the student has knowledge of the behavior of passive components at RF frequencies, knows the fabrication methods of components and is also able to apply the knowledge to
practical applications.

2. The student also knows the operating principles of transfer lines, antennas and filters and of their design.

3. The student can apply the fundamentals of RF and microwave techniques to measurements, is able to make the measurements of RF components, has knowledge of the operating principles of RF region measurement equipment and is able to compare the usability of different models.

4. The student knows how to perform typical measurements of RF region magnitudes (power, frequency, impedance and noise).

**Contents:**
Fundamentals of RF and microwave techniques, components in microwave circuits, measurement instruments, measuring of power, frequency, impedance and noise, time-domain and active circuit measurements.

**Mode of delivery:**
Face-to-face teaching, independent design exercises and laboratory exercises.

**Learning activities and teaching methods:**
Lectures 24 h, design exercises 20 h, laboratory exercises 20 h, independent work 68.5 h.

**Target group:**
Masters students on electrical engineering

**Prerequisites and co-requisites:**
The recommended prerequisite is the completion of the following courses prior to enrolling for the course unit: Electronic Components and Materials, Electronic Measurement Techniques, Basics of Radio Engineering.

**Recommended optional programme components:**
The course is an independent entity and does not require additional studies carried out at the same time.

**Recommended or required reading:**

**Assessment methods and criteria:**
Final exam, design exercises and laboratory exercises. 
Read more about assessment criteria at the University of Oulu webpage.

**Grading:**
The course utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

**Person responsible:**
Merja Teirikangas

**Working life cooperation:**
No.

**Other information:**
-

521405A: Electronic System Design, 5 cp

**Form of study:** Intermediate Studies

**Type:** Course

**Unit:** Electrical Engineering DP

**Grading:** 1 - 5, pass, fail

**Teachers:** Kari Määttä
Opintokohteen kielet (E): Finnish

ECTS Credits:
5

Language of instruction:
English/Finnish.

Timing:
Period 1

Learning outcomes:
1. is able to choose the optimum method of the choices presented in the course in the field of power supply, thermal design, grounding, and routing of the high speed signals. 
2. is able to calculate problems, caused by electrical disturbances, crosstalk and non-idealities of electrical components. 
3. can calculate reliability of an electrical device or system. 
4. The main goal of the course is to introduce methods and techniques needed in designing larger electronic entities such as equipment and systems.

Contents:
Power supplies, thermal design, grounding, transmission of fast signals by using transmission lines, electrical disturbances, crosstalk, non-idealities of electrical components.

Mode of delivery:
Face-to-face teaching.

Learning activities and teaching methods:
The course includes 30 h of lectures and 20 h of exercises.

Target group:
Primarily in electrical engineering students. Other University of Oulu students can complete the course.

Prerequisites and co-requisites:
Both Principles of Electronics Design and Analogue Electronics I must have been accepted.

Recommended optional programme components:
The course is an independent entity and does not require other studies carried out at the same time.

Recommended or required reading:

Assessment methods and criteria:
The course is passed by means of a final exam. 
Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course unit utilizes a numerical grading scale 0 - 5. In the numerical scale 0 stands for a fail.

Person responsible:
Kari Määttä

Working life cooperation:
No.

Other information:
-
No course descriptions.

Advanced module mandatory courses, choose min. 30 ECTS cr These are alternative: 521322S Telecommunication engineering project or 521300S Electronics design and construction exercise.

521386S: Radio Channels, 5 cp

Validity: 01.08.2011 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Pekka Kyöst, Markus Berg
Opintokohteen kielet (E): English

ECTS Credits:
5 ECTS credits / 130 hours of work
Language of instruction:
English
Timing:
Autumn, period 2.
Learning outcomes:
After completing the course, student
1. will be able to define what the radio channel is and is able to distinguish it into modellable parts.
2. knows different radio wave propagation mechanisms.
3. can apply physical and empirical radio channel models.
4. is able to analyse which are the dominating propagation mechanisms in different environments.
5. will know how to measure the properties of different radio channels.

Contents:

Mode of delivery:
Face-to-face teaching
Learning activities and teaching methods:
Lectures 24 h / Exercises 12 h / compulsory laboratory work 25 h / Self-study 74 h.

Target group:
1st or 2nd year M.Sc. and WCE students

Prerequisites and co-requisites:
The required (or recommended) prerequisite is the completion of the following courses prior to enrolling for the course: Basics of Radio Engineering, Signal Analysis

Recommended optional programme components:
The course is an independent entity and does not require additional studies carried out at the same time.

Recommended or required reading:

Assessment methods and criteria:
The course is passed with a final examination and the accepted laboratory work report.
Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible:
Markus Berg / Pekka Kyösti

Working life cooperation:
No

Other information:

521328A: Simulations and Tools for Telecommunications, 5 cp

Validity: 01.08.2015 -
Form of study: Intermediate Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Johanna Vartiainen
Opintokohteen kielet (E): Finnish
Leikkaavuudet (E):
  521369A  Simulations and Tools for Telecommunications   3.0 cp
  521369A-01 Simulations and Tools for Telecommunications, exam   0.0 cp
  521369A-02 Simulations and Tools for Telecomm. exercise   0.0 cp

ECTS Credits:
5
Language of instruction:
Finnish
Timing:
Fall, period 2
Learning outcomes:
1. A student recognizes problems and limitations related to simulations.

2. She/he can select a suitable simulation method and knows how to validate the model.

3. Student knows how to generate signals, random numbers and noise.

4. She/he knows how to model fading channels.

5. A student knows how to make Monte-Carlo simulations at the baseband level and can estimate confidence level of simulation results.

6. She/he can explain principles of network level simulations.

7. A student knows basics of one or two fundamental simulation programs

Contents:
Simulation methods, modelling communication systems with simulations, confidence limits of simulation, noise generation and modelling of fading channel. A simple baseband simulation example. Basics of MATLAB and OPNET simulation software (these could vary depending on needs/availability).

Mode of delivery:
Face-to-face teaching

Learning activities and teaching methods:
Lectures 24 h (including program introductions), and the compulsory assignment with a simulation program (40 h).

Target group:
3rd year bachelor's degree students and M.Sc. students

Prerequisites and co-requisites:
Telecommunication Engineering

Recommended optional programme components:
The course is an independent entity and does not require additional studies carried out at the same time.

Recommended or required reading:

Assessment methods and criteria:
The course is passed with a final examination and the accepted simulation work report. The final grade is based on exam. Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course unit utilizes a numerical grading scale 1-5.

Person responsible:
Johanna Vartiainen

Working life cooperation:
No

Other information:

521327S: Radio Engineering II, 6 cp

Validity: 01.08.2015 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Risto Vuohtoniemi, Aarno Pärssinen
Opintokohteen kielet (E): English
Leikkaavuudet (E):
- 521375S  Design of Tranceivers  5.0 cp
- 521375S-01  Design of tranceivers, partial credit  0.0 cp
- 521375S-02  Exercise work, Radio Engineering II  0.0 cp

ECTS Credits:
6 ECTS cr
Language of instruction:
English
Timing:
Spring, period 3
Learning outcomes:
1. understands radio system and RF design for modern wireless equipment like cellular phones.
2. recognizes the blocks of a transceiver and can explain the operating principle of a transceiver.
3. can classify different architectures used in a single and a multi-antenna transceiver and understand the basis for them.
4. will be able to define parameters used in the transceiver system level design and can design a transceiver at the system level so that the requirements for the system are fulfilled.
5. knows nonlinear distortion and can design the automatic gain control in the system level.
6. will be able to explain factors, which are important for the selection of D/A- and A/D-converters and can derive various methods to create the in phase and the quadratute components of a received signal.
7. understands the principles of frequency synthesis in a transceiver.
8. understands principles of key implementation technologies of radio transceivers and relation to electronics.

Contents:
Designing a transceiver at the system level, transceiver architectures, performance characteristics of transceivers, nonlinearities, factors which limit the performance of a transceiver, placement of the A/D-converter in a receiver, frequency synthesis, design and implementation examples.

Mode of delivery:
Face-to-face teaching
Learning activities and teaching methods:
Lectures 32 h and the compulsory design exercise with ADS simulation software (54 h).

Target group:
1st year M.Sc. and WCE-RF students
Prerequisites and co-requisites:
Radio Engineering I

Recommended optional programme components:
Recommended or required reading:

Assessment methods and criteria:
The course is passed with a final examination and the accepted simulation work report. In the final grade of the course, the weight for the examination is 0.75 and that for the simulation work 0.25. Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course unit utilizes a numerical grading scale 1-5.

Person responsible:
Risto Vuohtoniemi, Aarno Pärssinen.

Working life cooperation:
No

Other information:

521377S: Communications Networks II, 7 cp

Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Mika Ylianttila
Opintokohteen kielet (E): English

ECTS Credits:
7 ECTS cr

Language of instruction:
English

Timing:
Spring, periods 3-4

Learning outcomes:

1. Upon completing the required coursework, the students understand basic principles of programmable networking. The students understand the challenges in existing architectures and how Software Defined Networking (SDN) can solve those challenges.
2. Students understand the idea of SDN network control and data planes, and what it means in practice. The students learn how the network control-data plane separation is possible with SDN. The students have knowledge of how different control plane architectures can be developed or used for different networked environments.
3. Students understand the novel features in the 5G architecture, such as Multi-Access Edge Computing (MEC) and Network Function Virtualization (NFV) and the benefits of MEC and NFV for mobile networks. Students understand the importance of edge computing and virtualization techniques in achieving the low-latency and reliability requirements of 5G standard. Students know the planned use cases of multi-access edge computing in 5G systems and can describe some of the system architecture components.
4. Students understand the significance of network security, network load-balancing and network slicing in modern and emerging communications networks and how they need to be taken into consideration when using SDN and NFV.
5. Students understand the dynamics of simple programmable networks, the importance of queuing systems in the current model of programmable networks such as OpenFlow-based SDNs. The student is also able to design a queuing system for SDN-based network control plane to provide services in a balanced way to the underlying data plane the control plane is responsible for.

6. Students understand the basic principles of queueing theory, such as Birth and Death Process, the M/M/1, M/M/c, M/M/c/K and queuing networks models. Students understand concept of Markov model and its application in communication network analysis. Students can apply queueing theory to model SDN or virtualized networks.

7. Students learn skills to design and implement simple SDNs and analyze performance in network emulation and simulation environments.

Contents:
Introduction to the concepts of Software Defined Networking (SDN): the OpenFlow based SDN architecture, SDN control plane and data plane (OpenFlow switches), Software Defined Monitoring, SDN and Network Function Virtualization (NFV) integration in cellular systems. Introduction to Multi-Access Edge computing (MEC), and the use cases of MEC in 5G, and MEC-IoT integration. Introduction to queueing theory and queueing systems and application of queueing theory to model software defined mobile network or virtualized networks (Jackson network). Furthermore, the course discusses the significance of network security, network load-balancing and network slicing in modern and emerging communications networks. Course provides hands-on experience on virtual networks using SDN with Mininet network emulator.

Mode of delivery:
Face-to-face teaching

Learning activities and teaching methods:
Lectures 30 h, exercises 15 h and the compulsory design work with a simulation program (30 h). Description of Mininet exercises and Simulink simulation design work are provided in digital learning environment (Optima / Moodle).

Target group:
1st year M.Sc. and WCE students.

Prerequisites and co-requisites:
Communications Networks I

Recommended optional programme components:
The course is an independent entity and does not require additional studies carried out at the same time.

Recommended or required reading:

Assessment methods and criteria:
The course is passed with a final examination and the accepted emulation/simulation work report. The final grade is based on examination. Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course unit utilizes a numerical grading scale 1-5.

Person responsible:
Mika Ylianttila

Working life cooperation:
No

Other information:

521388S: Antennas, 5 cp
Validity: 01.08.2015 - 
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Markus Berg
Opintokohteen kielet (E): English
Leikkaavuudet (E):
  521380S  Antennas  4.0 cp
  521380S-01  Antennas, partial credit  0.0 cp
  521380S-02  Antennas, partial credit  0.0 cp

ECTS Credits:
5 ECTS credits / 135 hours of work

Language of instruction:
English

Timing:
Spring, period 4

Learning outcomes:
After completing the course, student
1. knows antenna terminology and understands the role of antennas as a part of different radio systems.
2. is familiar with the theories explaining the electromagnetic radiation of usual antenna types and antenna arrays.
3. will be able to design wire antennas, micro strip antennas and antenna arrays for different radio systems.
4. will be able to design and analyze various antenna types and arrays using 3D electromagnetic simulation software.

Contents:

Mode of delivery:
Face-to-face teaching

Learning activities and teaching methods:
Lectures and exercises 40 h / Compulsory antenna design work with an electromagnetic simulation 25 h / Self-study 70 h

Target group:
1st or 2nd year M.Sc. and WCE students

Prerequisites and co-requisites:
The required prerequisite is the completion of the following courses prior to enrolling for the course:
Basics of Radio Engineering 521384A

Recommended optional programme components:
The course is an independent entity and does not require additional studies carried out at the same time.

Recommended or required reading:

**Assessment methods and criteria:**
The course is passed with a final examination and the accepted design work report. In the final grade of the course, the weight for the examination is 0.5 and that for the design work 0.5.

Read more about the [assessment criteria](#) at the University of Oulu webpage.

**Grading:**
The course utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

**Person responsible:**
Markus Berg

**Working life cooperation:**
No

**Other information:**
- 

**521279S: Signal Processing Systems, 5 cp**

- **Validity:** 01.08.2012 - 
- **Form of study:** Advanced Studies
- **Type:** Course
- **Unit:** Computer Science and Engineering DP
- **Grading:** 1 - 5, pass, fail
- **Teachers:** Pekka Sangi
- **Opintokohteen kielet (E):** Finnish

**ECTS Credits:**
5 ECTS cr

**Language of instruction:**
English

**Timing:**
Autumn, period 2

**Learning outcomes:**
1. Student can explain the challenges of signal processing hardware, software, and design methodologies.

2. Student is able to transform a digital filter designed with floating point arithmetic into a fixed point precision implementation, optimizing the word lengths to achieve the performance specifications.

3. Student is able to explain the most important algorithm implementation structures and can identify their usage contexts.

4. Student has rudimentary practical skills in modeling, designing, and judging finite word length signal processing algorithms with Matlab and Simulink software tools.

**Contents:**
Binary and floating point arithmetic, DSP programming models and co-design, digital signal processors, algorithms and implementations, including CORDIC, transforms (FFT and DCT), multi-rate signal processing, polyphase filters, filter banks, adaptive algorithms and applications. The software environments of the course are Matlab with the Fixed Point Toolbox extension and Simulink with the DSP Blockset extension.
Mode of delivery:
Lectures, independent work, group work.

Learning activities and teaching methods:
The course consists of lectures (30 h) and design exercises (6-12 h), the rest as independent work (33h).

Target group:
Computer Science and Engineering students: This is an advanced-level course intended for masters-level students, especially to those that are specializing into signal processing. Other Students of the University of Oulu.

Prerequisites and co-requisites:
521337A Digital Filters, 521267A Computer Engineering or 521286A Computer Systems, 8 ECTS cr or 521287A Introduction to Computer Systems, 5 ECTS cr

Recommended optional programme components:
The course is an independent entity and does not require additional studies carried out at the same time.

Recommended or required reading:
Lecture notes and exercise materials. Material is in English.

Assessment methods and criteria:
Grading is based on the evaluation of the design exercises, which are done during the course, and exams, which are arranged during the lectures.
Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course unit utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible:
Pekka Sangi

Working life cooperation:
None.

521322S: Telecommunication Engineering Project, 5 cp

Validity: 01.08.2015 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Markus Berg, Saarnisaari, Harri Tapani
Opintokohteen kielet (E): Finnish
Leikkaavuudet (E):
521387S Telecommunication Engineering Project 4.0 cp

ECTS Credits:
5 ECTS credits / 135 hours of work
Language of instruction:
English/Finnish
Timing:
Fall or Spring, periods 1-4
Learning outcomes:
After completing the course student can
1. depending on the work subject, either solve, design, construct, measure, simulate, test or analyze limited telecommunication and radio system and sub-system problems.
2. apply the technical knowledge acquired from advanced sources into practical engineering tasks.
3. document technical and scientific results.

Contents:
Varies depending on the topic.

Mode of delivery:
Independent work.
If you would like to take the course, you can contact the course person responsible.

Learning activities and teaching methods:
The design exercise is done in a group of one or two students depending of work's difficulty. The design exercise can be simulation or implementation work. The work can be defined by the Department of Communications Engineering or by industry. In the later case a proposal must be submitted to the teacher before beginning of the work. Also, student must meet the schedule and deadlines given by a supervisor before starting the work. In preparing the work report document the writing instructions of DCE department's diploma thesis must be followed.

Target group:
1st or 2nd year M.Sc. and WCE students

Prerequisites and co-requisites:
Depending on the subject: advanced courses dealing with telecommunication systems, digital communications, digital signal processing or/and radio engineering.

Recommended optional programme components:
The course is an independent entity and does not require additional studies carried out at the same time.

Recommended or required reading:
Varies depending on the topic.

Assessment methods and criteria:
Written work report.
Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible:
Markus Berg / Harri Saarnisaari

Working life cooperation:
No

Other information:
-

521300S: Electronics Design and Construction Exercise, 6 cp

Validity: 01.08.2015 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Kari Määttä

Opintokohteen kielet (E): Finnish
Leikkaavuudet (E):

521441S Electronics Design and Construction Exercise 6.5 cp
ECTS Credits: 6

Language of instruction: Finnish, English

Timing: Periods 1-4

Learning outcomes:
1 is able to carry out all the stages needed to develop an electronic circuit or device starting from independent creation and design work to realization, testing and technical documentation.
2 is able to use independently without any help professional methods, software packages, measurement devices and tools.
3 Objective: To familiarize the student with independent electrical circuit and system design and with the methods and tools used in the design process. The course prepares the student for the diploma work in the area of circuits and system design.

Contents:
Design and construction of an electronic device or a part of a device according to the given specification. The task can be part of an industrial research or a product design project or part of the research project going on in Electronics or other laboratory. The subject of the work can be own suggestion of the student or a pre-selected course subject, which enables comprehensive training of skills needed for the design of a modern electronic device.

Mode of delivery:
Independent work.

Learning activities and teaching methods:
Independent design and construction work 180h

Target group:
Primarily in electrical engineering students. Other University of Oulu students can complete the course

Prerequisites and co-requisites:
Student must have passed following courses: Analogue Electronics I-II, Digital Techniques I-II, Electronic System Design and Filter Theory.

Recommended optional programme components:
The course is an independent entity and does not require other studies carried out at the same time.

Recommended or required reading:
Not defined

Assessment methods and criteria:
The task can be carried out by a student or by a team of two students. The grade will be decided on the basis of the statement of the instructor, realization of the device and the report provided by the student. Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course unit utilizes a numerical grading scale 0 - 5. In the numerical scale 0 stands for a fail.

Person responsible:
Kari Määttä

Working life cooperation:
No

521318S: Modern Topics in Telecommunications and Radio Engineering, 3 - 7 cp

Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Matti Latva-aho, Jari Iinatti
Opintokohteen kielet (E): English
Voidaan suorittaa useasti (E): Yes

ECTS Credits:
3-7
Language of instruction:
English
Timing:
Fall & Spring, periods 1-4
Learning outcomes:
After completing the course the student understand and is able to analyze basic principles of the topic which has been presented in the course. The final outcomes will be defined based on the contents.
Objective: Depending on each year’s topic, the course gives either an overview or deepens knowledge of actual topics and applications on radio techniques and telecommunications. The course comprises varying topical subjects, applications, research areas. Depending on the subject, the course may comprise a seminar of essays that practices a student for spontaneously acquiring information, improves readiness for making a master's thesis and readiness for performing in front of an audience.
Contents:
Varies yearly based on actual topics in telecommunications and radio engineering.
Mode of delivery:
Face-to-face teaching
Learning activities and teaching methods:
Lectures and/or exercises and/or design exercise and/or seminars depending on the topic of the year. The start and implementation of the course will be informed separately. The course can be given several times with different contents during the academic year and it can be included into the degree several times.
Target group:
1st and 2nd year M.Sc. and WCE students.
Prerequisites and co-requisites:
Will be defined based on the contents.
Recommended optional programme components:
-
Recommended or required reading:
Will be defined in the beginning of the course.
Assessment methods and criteria:
Depends on the working methods.
Grading:
The course unit utilizes a numerical grading scale 1-5.
Read more about assessment criteria at the University of Oulu webpage.
Person responsible:
Matti Latva-aho, Jari Iinatti
Working life cooperation:
-
Other information:
521389S: Wireless Body Area Networks, 5 cp

Validity: 01.08.2019 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Matti Hämäläinen
Opintokohteen kielet (E): English

ECTS Credits:
5 ECTS cr

Language of instruction:
English

Timing:
Spring, period 3-4, will be lectured first time in 2020

Learning outcomes:
Upon completing of the course, the student will be able to
1. distinguish the basic short range communications technologies used in the wireless body area network context,
2. understand the most relevant standards,
3. differentiate and compare the key points behind these standardized technologies and what are their advantages and disadvantages.
4. understand the major characteristics and applications utilizing WBAN and
5. understand the impact of wireless channels on the WBAN system and how channel affects to the WBAN system performance.

Contents:
Introduction, existing short range radio technologies, application, WBAN architecture, sensors & actuators & wearables, WBAN protocols, signal propagation within a human, WBAN antennas, WBAN transceivers, conclusion.

Mode of delivery:
Face-to-face teaching, compulsory seminar presentation

Learning activities and teaching methods:
Lectures 28 h + compulsory seminar presentation

Target group:
1st year WCE students and M.Sc. students (i.e., 4th year in EE degree programme). Special target group is students focusing on medical information and communications technologies.

Prerequisites and co-requisites:
-

Recommended optional programme components:
This course is an independent entity.

Recommended or required reading:
There is no recommended textbook for this course. Course material consists of lecture notes and selected publications.

Assessment methods and criteria:
Passing the course requires an accepted final exam and given seminar presentation.
Grading:
The course unit utilizes a numerical grading scale 1-5.

Person responsible:
Matti Hämäläinen

Working life cooperation:
No

Other information:
Course will be given every second year in even years. Will be held next time in Spring 2020.

521325S: Communication Signal Processing, 5 cp

Validity: 01.08.2015 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Juntti, Markku Johannes
Opintokohteen kielet (E): English
Leikkaavuudet (E):
521360S Synchronisation for Digital Receivers 4.0 cp
521360S-01 Exam, Communication Signal Processing II 0.0 cp
521360S-02 Synchronisation for Digital Receivers, exercise work 0.0 cp

ECTS Credits:
5 ECTS cr / 130 hours of work
Language of instruction:
English
Timing:
The course is held bi-annually in the spring semester, during period 4. It is recommended to complete the course at the 1st or 2nd spring semester of the master studies.

Learning outcomes:
Upon completion the student

1. knows the functional structure of communications transceiver and understands the requirements for various wireless systems for the transceiver.
2. knows the architectural and functional design of (all-)digital transceiver with synchronization, channel estimation, encoding/decoding, multiantenna processing and connection establishment.
3. understands the requirements of the current wireless communications standards and related multiplexing and multiple access on transceiver design.
4. can derive digital domain algorithms for separate functionalities and match them to operate together via agreed interfaces.
5. can model the operation of the algorithms and the whole transceiver using Matlab and C other to assess their performance by computer simulations.

Contents:
Wireless transceiver functional split, digital parts and architecture, multirate filtering and filter banks, transceiver digital front-end architecture and design, synchronization and channel estimation, equalization and soft detection, algorithm-architecture co-simulation, multiantenna transceivers.

Mode of delivery:
Face-to-face teaching and e-learning tool usage.
Learning activities and teaching methods:
Face-face-teaching (lectures, exercises and seminar presentations) 30 h, Simulation and design exercises and presentation preparation in groups 80 h, independent work & passed assignment 20 h.

Target group:
Electrical, communications and computer science and engineering students.

Prerequisites and co-requisites:
The required prerequisite is the completion of the following courses prior to enrolling for the course: 521348S Statistical signal processing I, 521324S Statistical Signal Processing II, 521323S Wireless communications I, 521317S Wireless communications II.

Recommended optional programme components:
-

Recommended or required reading:
Parts from books:
5. Other literature, lecture notes and material.

Assessment methods and criteria:
Completing the design and simulation projects, giving a seminar presentation on those, and a final exam. In the final grade of the course, the weight for the examination is 0.5 and that of project report 0.5.
Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course utilizes a numerical grading scale 1-5. In the numerical scale zero (0) stands for a fail.

Person responsible:
Markku Juntti

Working life cooperation:
The project focuses on timely design problems in wireless industry. Industrial visiting lectures are organized. The project can be done as true industrial design project.

Other information:
Course will be given every second year in odd years. Will be held next time in the spring of 2021.

521390S: Information Theory, 5 cp

Validity: 01.08.2019 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Hirley Alves, Markus Leinonen
Opintokohteen kielet (E): English

ECTS Credits:
5
Language of instruction:
English

Timing:
Fall, period 1, will be lectured first time in 2020

Learning outcomes:
Upon completing the required coursework, the student is able to use the basic methodology of information theory to calculate the capacity bounds of communication and data compression systems. He can estimate the feasibility of given design tasks before the execution of the detailed design. What is more, she can independently search for information and knowledge related to communication engineering, system design and signal processing.

Contents:
Enteropy, mutual information, data compression, basics of source coding, discrete channels and their capacity, the Gaussian channel and its capacity, rate distortion theory, quantization methods, introduction to network information theory, introduction to network coding, modern topics in information theory, compressed sensing, and information theory tools for machine learning.

Mode of delivery:
Face-to-face teaching

Learning activities and teaching methods:
Lectures and exercises 50 h, homework, seminar and compulsory lab assignments 30 h, independent work 50 h.

Target group:
2nd year M.Sc. electrical and communications engineering, WCE as well as computer science and engineering students

Prerequisites and co-requisites:
Signal Analysis, Telecommunication Engineering, Probability and Mathematical Statistics.

Recommended optional programme components:
Wireless Communications I and II, Statistical Signal Processing I and II.

Recommended or required reading:
Parts from books
Lecture notes and other literature.

Assessment methods and criteria:
The course is passed with two mid-term exams or with a final exam, and the accepted lab exercise report. The final grade is a weighted sum of exam (70%), homework and seminars (20%), and lab exercise (10%).

Grading:
The course unit utilizes a numerical grading scale 1-5.

Person responsible:
Hirley Alves/Markus Leinonen

Working life cooperation:
No

Other information:
Objective: To learn the information theory as a discipline and its most important applications in information technology in general and in communications engineering.

521391S: Channel Coding and Modulation, 5 cp
Validity: 01.08.2019 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Rajatheva Rajatheva
Opintokohteen kielet (E): English

ECTS Credits:
5
Language of instruction:
English
Timing:
Fall, period 1, next time in year 2021
Learning outcomes:
1. Student is fully conversant with commonly used error control coding techniques – block, convolutional, TCM, Lattice, Turbo, LDPC, Polar: code construction and decoding algorithms.
2. Student is able to evaluate the performance of a given code by analytical or computational-simulation methods.
3. Student is able to read and understand peer reviewed publications in Coding.

Contents:
Introduction: Groups, Rings, Fields, Construction of higher level Galois Fields, Factoring Linear, Cyclic and Convolutional codes – Viterbi and Sequential decoding Golay code, Reed Muller, Non binary BCH, Reed Solomon (RS) Codes and Decoding with Berlekamp Massey (BM) Algorithm Lattice Codes: Introduction to Coded Modulation, Ungerboeck and Forney Constructions, Packing, Covering, Vornoi Constellations Turbo Codes: BCJR Algorithm, Extrinsic Information, EXIT Chart Soft-input Soft-output (SISO) Decoding, Serial and Parallel concatenated codes, Application in 3G and 4G systems LDPC Codes: Low density parity check matrices, encoding, Decoding in a graph, QC-LDPC, Application in WiFi and enhanced mobile broadband (eMBB) in 5G Polar Codes: Successive Cancellation decoding, List decoding, Short frame codes, Control channel in 5G Applications and Developments: Satisfying latency and reliability in 5G through coding, Application of coding in Distributed Computing, Storage, Application of learning methods in coding

Mode of delivery:
Face-to-face teaching
Learning activities and teaching methods:
Lectures and exercises 50 h and compulsory homework and lab assignments 35 h.
Target group:
2nd year M.Sc. and WCE students
Prerequisites and co-requisites:
Probability and Statistics
Recommended optional programme components:
-
Recommended or required reading:
Assessment methods and criteria:
The course is passed with two mid-term exams or with final exam. The final grade is a weighted sum of exams (50%), homeworks (45%), and lab exercise (5%).

Grading:
The course unit utilizes a numerical grading scale 1-5.

Person responsible:
Nandana Rajatheva

Working life cooperation:
No

Other information:
Objective: Comprehensive course on coding techniques, including non binary constructions based on higher level Galois Fields, codes based on graphs and new applications. The course will start on Galois field constructions based on integer rings and continue with detailed Berlekamp-Massey Algorithm, Lattice Codes based on David Forney papers, Turbo, LDPC and Polar Codes as applied in 4G and 5G.

521392S: Convex Optimization, 7 cp

Validity: 01.08.2019 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Antti-Heikki Tölli, Italo Atzeni, Satya Joshi
Opintokohteen kielet (E): Finnish

ECTS Credits:
7 ECTS credits
Language of instruction:
English
Timing:
Autumn (periods 1 and 2)
Learning outcomes:
- The course introduces frameworks and systematic guidelines to handle mathematical optimization problems.
- The students will understand the basic tools and techniques to recognize, formulate, and reformulate various engineering problems as convex optimization problems.
- The students will understand the necessary and sufficient conditions for optimality; familiarize with dual problems; investigate the sensitivity of the optimal value with respect to perturbations.
- The students will be able to solve linear, quadratic, geometric, and semidefinite programming problems by using interior point methods; apply descent methods and Newton's methods; solve KKT systems.
- The students will familiarize with high-level optimization solvers and will be able to develop specific solvers/algorithms for their research problems.
- The students will be able to recognize the role of convex optimization in various engineering applications including signal processing, wireless communications, networking, and machine learning.

Contents:
1. Fundamental of convex analysis: convex sets, convex functions.
   a. Convex sets: affine and convex sets, operations that preserve convexity, separating and
      supporting hyperplanes, dual cones and generalized inequalities.
   b. Convex functions: convex, quasi-convex, log-convex, and conjugate functions, first-order
      condition, epigraph, sublevel sets, operations that preserve convexity, convexity with respect to
      generalized inequalities.
2. Optimization problems and transformations, local and global optima, optimality criterion, linear
   programming, quadratic programming, geometric programming, second-order cone
   programming, semidefinite programming, generalized inequality constraints, vector optimization.
3. Duality theory, geometric/saddle-point interpretation, optimality conditions, perturbation and
   sensitive analysis.
4. Applications to signal processing, wireless communications, and machine learning.
5. Algorithms for unconstrained/constrained optimizations: descent methods, Newton's method,
   interior-point methods.
6. Practical sessions using CVX.

Mode of delivery:
Face-to-face teaching

Learning activities and teaching methods:
Self-lectures, face-to-face lectures, exercises, and final project.

Target group:
Primarily communications engineering students. Other students from the University of Oulu can
complete the course.

Prerequisites and co-requisites:
In addition to courses 031025A “Introduction to optimization” and 031051S “Numerical matrix analysis”, a
working knowledge in digital communications, random processes, linear algebra, matrix manipulation
and detection theory is required.

Recommended optional programme components:

Recommended or required reading:
  2004.
- IEEE Magazine/Journals related to mathematical optimizations and applications.
- The course reader, homework with solutions, and other material by Prof. Boyd are available on his
  web page: http://web.stanford.edu/class/ee364a/
- The video lectures of Prof. Boyd are available on YouTube: https://www.youtube.com/watch?v=McLq1hEq3UY&list=PL3940DD956CDF0622

Assessment methods and criteria:
- 521392S: written exams (50%), exercises (25%), project work (25%).
- 520010J: written exams (40%), exercises (20%), project work (40%).

Grading:
The course unit utilizes a numerical grading scale (1-5).

Person responsible:
Antti Tölli, Satya Joshi, Italo Atzeni

Working life cooperation:
No

Other information:
For the academic year 2019/2020, the course 521392S (7 ECTS credits) will be held under the course
522010J.
The course content, self-lectures, face-to-face lectures, exercises, and written exams will be the same for 520010J (10 ECTS credits) and 521392S (7 ECTS credits). A larger and more involved project work will be required for 520010J with respect to 521392S.

- The first period will focus on the basic theoretical aspects and will consist of self-lectures and face-to-face lectures (one per week). Before each face-to-face lecture, the students will be required to watch a video lecture by Prof. Boyd, aided by the corresponding material. The first part of each face-to-face lecture will be devoted to recap and questions/clarifications from the self-lectures, while the second part will focus on practical examples and exercises.
- The second period will focus mostly on relevant applications and will consists of face-to-face lectures (two per week).

521393S: Statistical Communication Theory, 7 cp

Validity: 01.08.2019 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Rajatheva Rajatheva
Opintokohteen kielet (E): English

ECTS Credits:
7
Language of instruction:
English
Timing:
Fall, period 1-2, next time in 2020

Learning outcomes:
1. Student is conversant with commonly used estimation and detection techniques: receiver design and algorithms.
2. Student is able to evaluate the performance of a wireless receiver by analytical or simulation methods.
3. Student is able to read and understand peer reviewed publications in relevant topics.
4. Student is familiar with the novel applications in physical layer and new directions including 5G and beyond
5. Student can observe and explain the performance of these technologies with variable system and channel parameters through the course laboratory exercise – Vienna simulator.

Contents:
Detection of Signals – general Gaussian, ROC curves – performance, Estimation, Representation of Random Processes: Homogeneous Integral Equations and Eigenfunctions, Signals with unwanted parameters, Multiple channels, Mobility in Detection, Correlation functions: Bello functions – derivations, Waveforms for mm-wave and higher frequencies, Application of learning methods in Physical layer

Mode of delivery:
Face-to-face teaching

Learning activities and teaching methods:
Lectures and exercises 70 h and compulsory home assignments and lab 50 h

Target group:
2nd year M.Sc. and WCE students

Prerequisites and co-requisites:
Signals and Systems, Probability, Random Variables and Processes, Linear Algebra
Recommended optional programme components:
Wireless Communications I, Statistical Signal Processing I

Recommended or required reading:
Parts from books

Assessment methods and criteria:
The course is passed two mid-term exams or with final exam.
The final grade is a weighted sum of exam (50%), home assignments (45%), and lab exercise (5%).

Grading:
The course unit utilizes a numerical grading scale 1-5.

Person responsible:
Nandana Rajatheva

Working life cooperation:
No

Other information:
Objective is to develop a theoretical understanding of statistical communication theory.

521394S: Multiantenna Communications, 5 cp

Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Antti-Heikki Tölli
Opintokohteen kielet (E): English

ECTS Credits:
5

Language of instruction:
English

Timing:
Fall, period 1

Learning outcomes:
1. Upon completing the coursework, the student will have a deep understanding of the fundamental multiantenna transmission and reception concepts used in broadband wireless systems.
2. The student understands and can derive the channel capacity for various multiple-input multiple-output (MIMO) communication scenarios, can explain the effect of having the channel state information at the transmitter, and is acquainted with physical modelling of MIMO channels.
3. The student have knowledge of generalized MIMO transmitter and receiver structures for scenarios with and without channel state information. Both linear and non-linear transceiver structures are covered. The Massive MIMO foundations are reviewed including a brief introduction to the its analysis via random matrix theory.
4. After learning the basics in a single-user MIMO communications, the student is acquainted with the basic principles for multiuser multiantenna communications in fading channels and can derive the capacity region for MIMO multi-access and broadcast channels.
5. After the course, the student has also gained understanding on the applicability of multiuser MIMO communication and interference management schemes in realistic multi-cell scenarios, and how these technologies are deployed in current and future wireless systems and standards. In addition, hybrid beamforming and low precision quantization schemes are covered especially intended for mmWave and TeraHz communication scenarios.

Contents:
Point-to-point MIMO communications, multiuser multiple antenna communications in uplink and downlink, opportunistic communications, massive MIMO, beamforming for mmWave, scheduling and interference management, coordinated multi-cell transmission.

Mode of delivery:
Face-to-face teaching

Learning activities and teaching methods:
Lectures and exercise (total 40 hours) and the compulsory design work with a simulation program (20 h).

Target group:
Target group 2nd year WCE students and M.Sc. students (i.e., 5th year in ECE degree programme).

Prerequisites and co-requisites:
“521317S Wireless Communications II”, 521348S “Statistical Signal Processing I”, 031025A “Introduction to optimization” and 031051S “Numerical matrix analysis”, a working knowledge in digital communications, random processes, linear algebra, matrix manipulation and detection theory is required.

Recommended optional programme components:
Recommended optional programme components Prior knowledge of 521390S Information Theory, 521324S Statistical Signal Processing II and 521392S Convex Optimisation is very useful but not mandatory.

Recommended or required reading:

Assessment methods and criteria:
The course is passed with a final examination and the accepted simulation work report. The final grade is a weighted sum of exam (70%), homeworks (20%), and work report (10%).

Grading:
The course unit utilizes a numerical grading scale 1-5.

Person responsible:
Antti Tölli

Working life cooperation:
No

Other information:
Course will be given every second year in odd years. Will be held next time in Fall 2021.
Radio engineering - advanced module

521435S: Electronics Design III, 6 cp

Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Ilkka Nissinen
Opintokohteen kielet (E): Finnish

ECTS Credits:
6

Language of instruction:
In Finnish (English as a book examination)

Timing:
Autumn, period 2

Learning outcomes:
1. On completion of the study module students should be able to detail the advantages of differential signal processing in IC realizations and
2. to analyze and design differential amplifiers and other electronic blocks for implementation in an IC environment.
3. They should be able to explain how an SC (switched capacitor) technology functions and to apply such a technology to sampling and filtering.
4. They should also be able to describe the principles for realizing continuous filters in IC technologies, to explain the principles of the delta-sigma technology
5. and to apply it for realizing integrated DA and AD converters.
6. They should be able to account for the functioning, use and architecture of a phase-locked loop,
7. to explain the functioning of an MOS transistor in the area of weak inversion and to indicate how use can be made of this functional area in circuit design.

Contents:
Advanced operational amplifier topologies, especially differential ones, bandgap and PTAT bias circuits and references, problems related to the design of multi-stage amplifiers (output stages, LP/LV implementations), signal sampling and error sources related to it, SC-techniques (especially in filters), implementation principles of continuous time IC filters, DS techniques in general and particularly in AD /DA converters, operations with frequency/phase domain signals, design of IC layout.

Mode of delivery:
Face-to-face teaching

Learning activities and teaching methods:
Lectures 30h and Exercises 20 h and 4h layout demo. Self-study or in a group of two persons: laboratory exercise 36 h (CAD tools used in IC design and familiarization into the complete analogue IC design flow) and learning without guidance either privately or in a group 69 h.

Target group:
Electrical Engineering students and other Students of the University of Oulu.

Prerequisites and co-requisites:
Electronics Design II, Filters, Introduction to Microfabrication Techniques (recommended).

Recommended optional programme components:
The course is an independent entity and does not require additional studies carried out at the same time
Recommended or required reading:
Lecture notes
Assessment methods and criteria:
Passed final exam or 2 midterm exams and exercise work.
Read more about assessment criteria at the University of Oulu webpage.
Grading:
Numerical grading scale 1-5.
Person responsible:
Ilkka Nissinen
Working life cooperation:
No
Other information:
521327S: Radio Engineering II, 6 cp
Validity: 01.08.2015 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Risto Vuotoniemi, Aarno Pärssinen
Opintokohteen kielet (E): English
Leikkaavuudet (E):
521375S Design of Tranceivers 5.0 cp
521375S-01 Design of tranceivers, partial credit 0.0 cp
521375S-02 Exercise work, Radio Engineering II 0.0 cp
ECTS Credits:
6 ECTS cr
Language of instruction:
English
Timing:
Spring, period 3
Learning outcomes:
1. understands radio system and RF design for modern wireless equipment like cellular phones.
2. recognizes the blocks of a transceiver and can explain the operating principle of a transceiver.
3. can classify different architectures used in a single and a multi-antenna transceiver and understand the basis for them.
4. will be able to define parameters used in the transceiver system level design and can design a transceiver at the system level so that the requirements for the system are fulfilled.
5. knows nonlinear distortion and can design the automatic gain control in the system level.

6. will be able to explain factors, which are important for the selection of D/A- and A/D-converters and can derive various methods to create the in phase and the quadrature components of a received signal.

7. understands the principles of frequency synthesis in a transceiver.

8. understands principles of key implementation technologies of radio transceivers and relation to electronics.

Contents:
Designing a transceiver at the system level, transceiver architectures, performance characteristics of transceivers, nonlinearities, factors which limit the performance of a transceiver, placement of the A/D-converter in a receiver, frequency synthesis, design and implementation examples.

Mode of delivery:
Face-to-face teaching

Learning activities and teaching methods:
Lectures 32 h and the compulsory design exercise with ADS simulation software (54 h).

Target group:
1st year M.Sc. and WCE-RF students

Prerequisites and co-requisites:
Radio Engineering I

Recommended optional programme components:
-

Recommended or required reading:

Assessment methods and criteria:
The course is passed with a final examination and the accepted simulation work report. In the final grade of the course, the weight for the examination is 0.75 and that for the simulation work 0.25. Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course unit utilizes a numerical grading scale 1-5.

Person responsible:
Risto Vuohtoniemi, Aarno Pärssinen.

Working life cooperation:
No

Other information:
-

521075S: Microelectronics Packaging Technologies, 5 cp

Validity: 01.08.2015 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Sami Myllymäki
Opintokohteen kielet (E): Finnish
ECTS Credits:
5

Language of instruction:
Finnish

Timing:
3rd period

Learning outcomes:
1. Upon completing the course student can explain how electronics packaging technology has since invention of transistors to current date, and can estimate how this development is going to continue in future.

2. The student can describe can explain what is meant by microjoining techniques and what are the pros and cons of these.

3. The student can tell what different kind of materials, and why, are used in IC packaging technology.

4. The student can explain what is meant with system level packaging and how the strong miniaturization on IC requires new system level packaging techniques to be developed.

5. He can explain why active and passive components are being, more and more, embedded to be a part of the circuit board.

6. In addition he can explain why and how optoelectronics will be migrate towards circuit board and components on it.

Contents:

Mode of delivery:
Face to face teaching

Learning activities and teaching methods:
Lecturing 24 h, practical work 12 h.

Target group:
Primarily major students of electrical engineering.

Prerequisites and co-requisites:
Recommended Introduction to Microfabrication Techniques.

Recommended optional programme components:
The course is an independent entity and does not require additional studies carried out at the same time.

Recommended or required reading:

Assessment methods and criteria:
The course is completed with the final exam and finished course work.

Grading:
The course unit utilizes a numerical grading scale 1-5.

Person responsible:
Sami Myllymäki
Working life cooperation:
No
Other information:
-

521388S: Antennas, 5 cp

Validity: 01.08.2015 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Markus Berg
Opintokohteen kielet (E): English
Leikkaavuudet (E):

<table>
<thead>
<tr>
<th>Code</th>
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<td>Antennas</td>
<td>4.0 cp</td>
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<tr>
<td>521380S-01</td>
<td>Antennas, partial credit</td>
<td>0.0 cp</td>
</tr>
<tr>
<td>521380S-02</td>
<td>Antennas, partial credit</td>
<td>0.0 cp</td>
</tr>
</tbody>
</table>

ECTS Credits:
5 ECTS credits / 135 hours of work
Language of instruction:
English
Timing:
Spring, period 4
Learning outcomes:
After completing the course, student
1. knows antenna terminology and understands the role of antennas as a part of different radio systems.
2. is familiar with the theories explaining the electromagnetic radiation of usual antenna types and antenna arrays.
3. will be able to design wire antennas, micro strip antennas and antenna arrays for different radio systems.
4. will be able to design and analyze various antenna types and arrays using 3D electromagnetic simulation software.

Contents:

Mode of delivery:
Face-to-face teaching
Learning activities and teaching methods:
Lectures and exercises 40 h / Compulsory antenna design work with an electromagnetic simulation 25 h / Self-study 70 h

Target group:
1st or 2nd year M.Sc. and WCE students
Prerequisites and co-requisites:
The required prerequisite is the completion of the following courses prior to enrolling for the course:
Basics of Radio Engineering 521384A

Recommended optional programme components:
The course is an independent entity and does not require additional studies carried out at the same time.

Recommended or required reading:

Assessment methods and criteria:
The course is passed with a final examination and the accepted design work report. In the final grade of the course, the weight for the examination is 0.5 and that for the design work 0.5. Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible:
Markus Berg

Working life cooperation:
No

Other information:
-

521402S: Telecommunications Circuit Design, 6 cp

Validity: 01.08.2017 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Rahkonen, Timo Erkki
Opintokohteen kielet (E): Finnish

ECTS Credits:
6 ects / 42 contact hours + design excercise

Language of instruction:
English/Finnish

Timing:
Autumn, 1st period of the last year of studies

Learning outcomes:
After completing the course the student
- knows the most usual schematic structures and dimensioning principles of typical telecommunication circuit blocks
- can sketch the spectral effects of non-linear and time-varying circuit blocks
- can evaluate the performance of the available IC process node

Contents:
The course gives the background needed in the design of RFICs and other analog telecommunication circuit blocks.

Mode of delivery:
Face-to-face teaching

**Learning activities and teaching methods:**
28 hours of lectures, 14 of exercises, and a relatively large design task.

**Target group:**
Last year MSc students with strong analog design background

**Prerequisites and co-requisites:**
Strong background in analog transistor level design is required.

**Recommended optional programme components:**
Needs electronics design 2-3 background

**Recommended or required reading:**
Handouts

**Assessment methods and criteria:**
Graded based on the final exam. The design exercise needs to be passed.

**Grading:**
Numerical scale 0-5. 0 is fail, 5 the best.

**Person responsible:**
Prof. Timo Rahkonen

**Working life cooperation:**
The topics are strongly related to the skills needed in the industry

**Other information:**
The course is the last advanced course in analog design, and requires the basic knowledge of transistor level analog design and IC design.

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**Obligatory, Radio engineering - advanced module, Choose 521322S Telecommunication engineering project or 521300S Electronics design and construction exercise**

**521322S: Telecommunication Engineering Project, 5 cp**

**Validity:** 01.08.2015 -

**Form of study:** Advanced Studies

**Type:** Course

**Unit:** Electrical Engineering DP

**Grading:** 1 - 5, pass, fail

**Teachers:** Markus Berg, Saarnisaari, Harri Tapani

**Opintokohteen kielet (E):** Finnish

**Leikkaavuudet (E):**
521387S Telecommunication Engineering Project 4.0 cp

**ECTS Credits:**
5 ECTS credits / 135 hours of work

**Language of instruction:**
English/Finnish

**Timing:**
Fall or Spring, periods 1-4

**Learning outcomes:**
After completing the course student can
1. depending on the work subject, either solve, design, construct, measure, simulate, test or analyze limited telecommunication and radio system and sub-system problems.
2. apply the technical knowledge acquired from advanced sources into practical engineering tasks.
3. document technical and scientific results.

Contents:
Varies depending on the topic.

Mode of delivery:
Independent work.
If you would like to take the course, you can contact the course person responsible.

Learning activities and teaching methods:
The design exercise is done in a group of one or two students depending of work's difficulty. The design exercise can be simulation or implementation work. The work can be defined by the Department of Communications Engineering or by industry. In the later case a proposal must be submitted to the teacher before beginning of the work. Also, student must meet the schedule and deadlines given by a supervisor before starting the work. In preparing the work report document the writing instructions of DCE department's diploma thesis must be followed.

Target group:
1st or 2nd year M.Sc. and WCE students

Prerequisites and co-requisites:
Depending on the subject: advanced courses dealing with telecommunication systems, digital communications, digital signal processing or and radio engineering.

Recommended optional programme components:
The course is an independent entity and does not require additional studies carried out at the same time.

Recommended or required reading:
Varies depending on the topic.

Assessment methods and criteria:
Written work report.
Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible:
Markus Berg / Harri Saarnisaari

Working life cooperation:
No

Other information:
-  

521300S: Electronics Design and Construction Exercise, 6 cp

Validity: 01.08.2015 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Kari Määttä
Opintokohteen kielet (E): Finnish
Leikkaavuudet (E):

521441S  Electronics Design and Construction Exercise  6.5 cp
ECTS Credits:
6
Language of instruction:
Finnish, English
Timing:
Periods 1-4
Learning outcomes:
1 is able to carry out all the stages needed to develop an electronic circuit or device starting from independent creation and design work to realization, testing and technical documentation.
2 is able to use independently without any help professional methods, software packages, measurement devices and tools.
3 Objective: To familiarize the student with independent electrical circuit and system design and with the methods and tools used in the design process. The course prepares the student for the diploma work in the area of circuits and system design.
Contents:
Design and construction of an electronic device or a part of a device according to the given specification. The task can be part of an industrial research or a product design project or part of the research project going on in Electronics or other laboratory. The subject of the work can be own suggestion of the student or a pre-selected course subject, which enables comprehensive training of skills needed for the design of a modern electronic device.
Mode of delivery:
Independent work.
Learning activities and teaching methods:
Independent design and construction work 180h
Target group:
Primarily in electrical engineering students. Other University of Oulu students can complete the course
Prerequisites and co-requisites:
Student must have passed following courses: Analogue Electronics I-II, Digital Techniques I-II, Electronic System Design and Filter Theory.
Recommended optional programme components:
The course is an independent entity and does not require other studies carried out at the same time.
Recommended or required reading:
Not defined
Assessment methods and criteria:
The task can be carried out by a student or by a team of two students. The grade will be decided on the basis of the statement of the instructor, realization of the device and the report provided by the student. Read more about assessment criteria at the University of Oulu webpage.
Grading:
The course unit utilizes a numerical grading scale 0 - 5. In the numerical scale 0 stands for a fail.
Person responsible:
Kari Määttä
Working life cooperation:
No

A453246: Supplementary module/Electives, Wireless Communications Engineering, 10 - 41 cp
Validity: 01.08.2005 -
No course descriptions.

*Radio engineering (WCE-RF): Optional courses, Choose 5 ECTS cr*

**521386S: Radio Channels, 5 cp**

- **Validity:** 01.08.2011 - 
- **Form of study:** Advanced Studies
- **Type:** Course
- **Unit:** Electrical Engineering DP
- **Grading:** 1 - 5, pass, fail
- **Teachers:** Pekka Kyösti, Markus Berg
- **Opintokohteen kielet (E):** English

**ECTS Credits:**
5 ECTS credits / 130 hours of work

**Language of instruction:**
English

**Timing:**
Autumn, period 2.

**Learning outcomes:**
After completing the course, student
1. will be able to define what the radio channel is and is able to distinguish it into modellable parts.
2. knows different radio wave propagation mechanisms.
3. can apply physical and empirical radio channel models.
4. is able to analyse which are the dominating propagation mechanisms in different environments.
5. will know how to measure the properties of different radio channels.

**Contents:**

**Mode of delivery:**
Face-to-face teaching

**Learning activities and teaching methods:**
Lectures 24 h / Exercises 12 h / compulsory laboratory work 25 h / Self-study 74 h.

**Target group:**
1st or 2nd year M.Sc. and WCE students

**Prerequisites and co-requisites:**
The required (or recommended) prerequisite is the completion of the following courses prior to enrolling for the course: Basics of Radio Engineering, Signal Analysis

**Recommended optional programme components:**
The course is an independent entity and does not require additional studies carried out at the same time.

**Recommended or required reading:**

**Assessment methods and criteria:**
The course is passed with a final examination and the accepted laboratory work report. Read more about assessment criteria at the University of Oulu webpage.

**Grading:**
The course utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

**Person responsible:**
Markus Berg / Pekka Kyösti

**Working life cooperation:**
No

**Other information:**
- 521328A: Simulations and Tools for Telecommunications, 5 cp

**Validity:** 01.08.2015 -

**Form of study:** Intermediate Studies

**Type:** Course

**Unit:** Electrical Engineering DP

**Grading:** 1 - 5, pass, fail

**Teachers:** Johanna Vartiainen

**Opintokohteen kielet (E):** Finnish

**Leikkaavuudet (E):**
- 521369A Simulations and Tools for Telecommunications 3.0 cp
- 521369A-01 Simulations and Tools for Telecommunications, exam 0.0 cp
- 521369A-02 Simulations and Tools for Telecomm. exercise 0.0 cp

**ECTS Credits:**
5

**Language of instruction:**
Finnish

**Timing:**
Fall, period 2

**Learning outcomes:**
1. A student recognizes problems and limitations related to simulations.
2. She/he can select a suitable simulation method and knows how to validate the model.
3. Student knows how to generate signals, random numbers and noise.
4. She/he knows how to model fading channels.

5. A student knows how to make Monte-Carlo simulations at the baseband level and can estimate confidence level of simulation results.

6. She/he can explain principles of network level simulations.

7. A student knows basics of one or two fundamental simulation programs

Contents:
Simulation methods, modelling communication systems with simulations, confidence limits of simulation, noise generation and modelling of fading channel. A simple baseband simulation example. Basics of MATLAB and OPNET simulation software (these could vary depending on needs/availability).

Mode of delivery:
Face-to-face teaching

Learning activities and teaching methods:
Lectures 24 h (including program introductions), and the compulsory assignment with a simulation program (40 h).

Target group:
3rd year bachelor's degree students and M.Sc. students

Prerequisites and co-requisites:
Telecommunication Engineering

Recommended optional programme components:
The course is an independent entity and does not require additional studies carried out at the same time.

Recommended or required reading:

Assessment methods and criteria:
The course is passed with a final examination and the accepted simulation work report. The final grade is based on exam. Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course unit utilizes a numerical grading scale 1-5.

Person responsible:
Johanna Vartiainen

Working life cooperation:
No

Other information:
-

521340S: Communications Networks I, 5 cp

Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Mika Ylianttila
Opintokohteen kielet (E): English

ECTS Credits:
5 ECTS cr

Language of instruction:
English

Timing:
Fall, period 2

Learning outcomes:
1. Students understand how the modern communications networks have evolved and how the architecture has changed through the recent paradigm shift towards software-centric communications.
2. Students are able to describe the basic system architecture elements of mobile networks, and understands the significance of emerging technologies such as Network Function Virtualization (NFV), Software Defined Networking (SDN), and core network functionalities such as Evolved Packet Core (EPC).
3. Students can describe the main principles of mobility management, network management and orchestration, and network security, and can apply and solve related engineering problems.
4. Students know the basic properties of routing algorithms, and can use graph theory to solve network routing problems.
5. Students are able to simulate different types of networks in simulation environments and solve basic network programming problems. Upon completing the required coursework, students understand the basic functionalities in TCP/IP protocol stack.

Contents:
Communications architecture in mobile, wireless local area and personal area networks. Introduction to cloud and edge computing, network function virtualization and software defined networking. Basic principles of mobility management, network security, network management and orchestration. The goal is to present the basics of the modern communications architectures, and their technical implementation.

Mode of delivery:
Face-to-face teaching.

Learning activities and teaching methods:
Lectures 30 h and the compulsory design work (15 h). Design work can be done alternatively either as NS-2 simulation or TCP/IP programming exercise. Design work instructions are provided in digital learning environment (Optima / Moodle).

Target group:
1st year M.Sc. and WCE students

Prerequisites and co-requisites:
-

Recommended optional programme components:
The course is an independent entity and does not require additional studies carried out at the same time.

Recommended or required reading:
Software Defined Mobile Networks (SDMN): Beyond LTE Network Architecture, M Liyanage, A Gurtov, M Ylianttila – 2015; A comprehensive Guide to 5G Security, M Liyanage, I Ahmad, A Abro, A Gurtov, M Ylianttila – 2018; In addition, selected supportive online reading materials from recent standards and publications are provided in digital learning environment (Optima / Moodle).

Assessment methods and criteria:
The course is passed with a final examination and the accepted design work report. The final grade is based on examination.
Read more about assessment criteria at the University of Oulu webpage.
Grading:
The course unit utilizes a numerical grading scale 1-5.

Person responsible:
Mika Ylianttila

Working life cooperation:
No

Other information:
-

521349S: Wireless Communications II, 5 cp

Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Antti-Heikki Tölö
Opintokohteen kielet (E): English

ECTS Credits:
5

Language of instruction:
English

Timing:
Spring, periods 3-4

Learning outcomes:
1. The student is familiarised with the channel capacity as the fundamental performance measure of wireless communication links, and can explain the effect of fading channel on the capacity in a single-user single-antenna scenarios.
2. The student understands the basic principles for multiuser communications in fading channels, apprehends the notion of capacity region for multi-access and broadcast channels, and is familiarised with different practical multiple access, random access and scheduling methods.
3. The student is acquainted with core principles of adaptive transmission, which requires accurate channel estimates at the receiver and a reliable information exchange mechanisms between the receiver and transmitter. Practical variable-rate variable-power MQAM modulation techniques for fading channels are introduced.
4. The student understands the principles of transmitter and receiver design in the presence of channel distortion. The student is familiarised with various (adaptive) equalization solutions to combat intersymbol interference.
5. Finally, the student is acquainted with the capacity optimal multi-antenna transmission and reception scheme, as well as, with basic multiantenna space-time coding schemes in a single-user multiple-input multiple-output (MIMO) communications scenario.

Contents:
Capacity of wireless channels, multiuser communications, adaptive modulation and coding, equalization, point-to-point MIMO communications and space-time coding.

Mode of delivery:
Face-to-face teaching

Learning activities and teaching methods:
Lectures and exercise (total 40 hours) and the compulsory design work with a simulation program (20 h).

Target group:
1st year WCE students and M.Sc. students (i.e., 4th year in ECE degree programme).

Prerequisites and co-requisites:
In addition to courses “521395S Wireless Communications I”, 521348S “Statistical Signal Processing I”, 031025A “Introduction to optimization” and 031051S “Numerical matrix analysis”, a working knowledge in digital communications, random processes, linear algebra, matrix manipulation and detection theory is required.

Recommended optional programme components:
Prior knowledge of 521390S Information Theory and 521392S Convex Optimisation is very useful but not mandatory. The course 521324S Statistical Signal Processing II is recommended to be taken in parallel.

Recommended or required reading:

Assessment methods and criteria:
The course is passed with a final examination and the accepted simulation work report. The final grade is a weighted sum of exam (70%), homework (20%), and work report (10%).

Grading:
The course unit utilizes a numerical grading scale 1-5.

Person responsible:
Antti Tölli

Working life cooperation:
No

Other information:
Course replaces the old course 521317S Wireless Communications II (8cr).

521325S: Communication Signal Processing, 5 cp

Validity: 01.08.2015 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Juntti, Markku Johannes
Opintokohteen kielet (E): English
Leikkaavuudet (E):
  521360S  Synchronisation for Digital Receivers  4.0 cp
  521360S-01  Exam, Communication Signal Processing II  0.0 cp
  521360S-02  Synchronisation for Digital Receivers, exercise work  0.0 cp

ECTS Credits:
5 ECTS cr / 130 hours of work
Language of instruction:
English
Timing:
The course is held bi-annually in the spring semester, during period 4. It is recommended to complete the course at the 1st or 2nd spring semester of the master studies.
Learning outcomes:
Upon completion the student

1. knows the functional structure of communications transceiver and understands the requirements for various wireless systems for the transceiver.
2. knows the architectural and functional design of (all-)digital transceiver with synchronization, channel estimation, encoding/decoding, multiantenna processing and connection establishment.
3. understands the requirements of the current wireless communications standards and related multiplexing and multiple access on transceiver design.
4. can derive digital domain algorithms for separate functionalities and match them to operate together via agreed interfaces.
5. can model the operation of the algorithms and the whole transceiver using Matlab and C other to assess their performance by computer simulations.

Contents:
Wireless transceiver functional split, digital parts and architecture, multirate filtering and filter banks, transceiver digital front-end architecture and design, synchronization and channel estimation, equalization and soft detection, algorithm-architecture co-simulation, multiantenna transceivers.

Mode of delivery:
Face-to-face teaching and e-learning tool usage.

Learning activities and teaching methods:
Face-face-teaching (lectures, exercises and seminar presentations) 30 h, Simulation and design exercises and presentation preparation in groups 80 h, independent work & passed assignment 20 h.

Target group:
Electrical, communications and computer science and engineering students.

Prerequisites and co-requisites:
The required prerequisite is the completion of the following courses prior to enrolling for the course: 521348S Statistical signal processing I, 521324S Statistical Signal Processing II, 521323S Wireless communications I, 521317S Wireless communications II.

Recommended optional programme components:
-

Recommended or required reading:
Parts from books:
5. Other literature, lecture notes and material.

Assessment methods and criteria:
Completing the design and simulation projects, giving a seminar presentation on those, and a final exam. In the final grade of the course, the weight for the examination is 0.5 and that of project report 0.5.
Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course utilizes a numerical grading scale 1-5. In the numerical scale zero (0) stands for a fail.

Person responsible:
Markku Juntti

Working life cooperation:
The project focuses on timely design problems in wireless industry. Industrial visiting lectures are organized. The project can be done as true industrial design project.

Other information:
Course will be given every second year in odd years. Will be held next time in the spring of 2021.

WCE-RAN and WCE-RF

900017Y: Survival Finnish, 2 cp

Validity: 01.08.1995 -
Form of study: Language and Communication Studies
Type: Course
Unit: Languages and Communication
Grading: 1 - 5, pass, fail
Opintokohteen kielet (E): Finnish
Leikkaavuudet (E):
   ay900017Y  Survival Finnish Course (OPEN UNI)  2.0 cp

Proficiency level:
A1.1
Status:
The course is intended for the international students in every faculty of Oulu University.
Required proficiency level:
No previous Finnish studies.
ECTS Credits:
2 ECTS credits
Language of instruction:
Finnish and English
Timing:
-
Learning outcomes:
By the end of the course the student can understand and use some very common everyday expressions and phrases, and s/he can locate informational content in simple texts and messages. The student also knows the basic characteristics of Finnish language and Finnish communication styles.
Contents:
This is an introductory course which aims to help students to cope with the most common everyday situations in Finnish. During the course, students learn some useful everyday phrases, some general features of the vocabulary and grammar, and the main principles of pronunciation.

The topics and communicative situations covered in the course are: general information about the Finnish language, some politeness phrases (how to greet people, thank and apologize), introducing oneself, giving and asking for basic personal information, numbers, some time expressions (how to tell and ask the time, days of the week, time of day), food, drink and asking about prices.

The structures studied are: personal pronouns and their possessive forms, forming affirmative, negative and interrogative sentences, the conjugation of some verbs, the basics of the partitive singular and some local cases for answering the 'where'-question.

Mode of delivery:
Contact teaching, on-line learning and independent work. There will be organized also one on-line group in each semester.
Learning activities and teaching methods:
Lessons 2 times a week (26 h, including the final exam) and guided self study (24 h)

Target group:
International degree and post-graduate degree students and exchange students of the University

Prerequisites and co-requisites:
-

Recommended optional programme components:
-

Recommended or required reading:
Will be provided during the course.

Assessment methods and criteria:
Regular and active participation in the weekly lessons (twice a week), homework assignments and written exam at the end of the course will be observed in assessment.
Read more about assessment criteria at the University of Oulu webpage.

Grading:
Grading scale is on a pass/fail basis.

Person responsible:
Anne Koskela

Working life cooperation:
-

Other information:
Sign-up in WebOodi.

900013Y: Beginners' Finnish Course 1, 3 cp

Validity: 01.08.1995 -
Form of study: Language and Communication Studies
Type: Course
Unit: Languages and Communication
Grading: 1 - 5, pass, fail
Opintokohteen kielet (E): Finnish
Leikkaavuudet (E):
   ay900013Y   Beginners' Finnish Course 1 (OPEN UNI)   2.0 cp

Proficiency level:
A1.2

Status:
The course is intended for the international students in every faculty of Oulu University.

Required proficiency level:
A1.1, Completion of the Survival Finnish course (900017Y) or the equivalent language skills.

ECTS Credits:
3 ECTS credits

Language of instruction:
As much Finnish as possible; English will be used as a help language.

Timing:
-
Learning outcomes:
By the end of the course the student can understand and use some familiar and common everyday expressions relating to her/himself and everyday situations. S/he can interact in a simple way provided the other person talks slowly and clearly and is willing to help. The student is able to read short simple texts and messages dealing with familiar topics. S/he also deepens her/his understanding of the Finnish language and communication styles.

Contents:
This is lower elementary course which aims to help students to learn communication skills in ordinary everyday situations. During the course, students broaden their vocabulary and knowledge of grammar and principles of pronunciation. They also practise to understand easy Finnish talk about everyday subjects, and reading and writing short and simple texts/messages.

The topics and communicative situations covered in the course are: talking about oneself, one's family, studies and daily routines, as well as asking about these things from other person, expressing opinions, describing people and things, talking about weather and seasons, the names of the months and colours.

The structures studied are: verb types, basics of the change of the consonants k, p and t in verbs and nouns, the genitive and partitive cases, possessive structure, some declension types for nouns (word types) and the basics of the local cases.

Mode of delivery:
Contact teaching and guided self study

Learning activities and teaching methods:
Lessons 2 times a week (26 h, including the final exam) and guided self study (55 h)

Target group:
International degree and post-graduate degree students and exchange students of the University

Prerequisites and co-requisites:
Completion of the Survival Finnish Course

Recommended optional programme components:
- 

Recommended or required reading:
Gehring, S. & Heinzmann, S. Suomen mestari 1 (chapters 3 - 5)

Assessment methods and criteria:
Regular and active participation in the weekly lessons (twice a week), homework assignments and written exam at the end of the course will be observed in assessment.
Read more about assessment criteria at the University of Oulu webpage.

Grading:
Grading scale is 1-5.

Person responsible:
Anne Koskela

Working life cooperation:
- 

Other information:
Sign-up in WebOodi. The course will start right after the Survival Finnish course.

900053Y: Beginners' Finnish Course 2, 5 cp

Validity: 01.08.1995 -

Form of study: Language and Communication Studies

Type: Course
Unit: Languages and Communication  
Grading: 1 - 5, pass, fail  
Opintokohteen kielet (E): Finnish  
Leikkaavuudet (E):  
  ay900053Y  Beginners' Finnish Course 2 (OPEN UNI)  4.0 cp

Proficiency level:  
A1.3

Status:  
The course is intended for the international students in every faculty of Oulu University.

Required proficiency level:  
A1.2, completion of the Beginners' Finnish course 1 (900013Y) or the equivalent language skills.

ECTS Credits:  
5 ECTS credits

Language of instruction:  
As much Finnish as possible; English will be used as a help language.

Timing:  
-

Learning outcomes:  
By the end of the course the student can understand and use some very common everyday expressions and sentences. S/he can communicate in easy and routine tasks requiring a simple and direct exchange of information on familiar everyday matters. The student understands different kinds of short texts. S/he can for example locate important information in them. In addition, s/he has acquired more detailed knowledge of the language and culture.

Contents:  
This is a post-elementary course. During the course students learn more about communication in ordinary everyday situations in Finnish. They also extend their vocabulary and knowledge of grammar. Students practise understanding simple Finnish talk and short texts.

The topics and communicative situations covered in the course are: asking for and giving directions, asking for help/favours, carrying out transactions in shops and restaurants, talking about the past, asking for and expressing opinions and feelings, accommodation, travelling, vehicles, work, professions, food, drink and parties.

The structures studied are: the local cases, nominative plural (basic form plural), imperfect (past tense of verbs), part of the imperative, more declension types for nouns (word types), more about the change of the consonants k, p and t in verbs and nouns, declension of the demonstrative pronouns and personal pronouns, more about the partitive case, basics of the object cases, postpositions and some sentence types in Finnish.

Mode of delivery:  
Contact teaching and guided self study

Learning activities and teaching methods:  
Lessons 2 times a week (52 h, including the tests) and guided self study (83 h)

Target group:  
International degree and post-graduate degree students and exchange students of the University

Prerequisites and co-requisites:  
Completion of the Beginners' Finnish Course 1

Recommended optional programme components:  
-
Recommended or required reading:
Gehring, S. & Heinzmann, S.: **Suomen mestari 1** (kappaleet 6-9)

Assessment methods and criteria:
Regular and active participation in the weekly lessons (twice a week), homework assignments and tests will be taken into consideration in the assessment. Read more about assessment criteria at the University of Oulu webpage.

Grading:
Grading scale is 1-5.

Person responsible:
Anne Koskela

Working life cooperation:
-

Other information:
Sign-up in WebOodi. The lessons will be held **twice a week** during a 13-week period.

521225S: RF Components and Measurements, 5 cp

**Form of study:** Advanced Studies

**Type:** Course

**Unit:** Electrical Engineering DP

**Grading:** 1 - 5, pass, fail

**Teachers:** Teirikangas, Merja Elina

Opintokohteen kielet (E): Finnish

**ECTS Credits:**
5 ECTS credits / 132,5 hours of work

**Language of instruction:**
Finnish. English, if there are at least 3 international students in class.

**Timing:**
The course is held in the 4th period. It is recommended to complete the course during Master level studies.

**Learning outcomes:**
1. After completing the course the student has knowledge of the behavior of passive components at RF frequencies, knows the fabrication methods of components and is also able to apply the knowledge to practical applications.

2. The student also knows the operating principles of transfer lines, antennas and filters and of their design.

3. The student can apply the fundamentals of RF and microwave techniques to measurements, is able to make the measurements of RF components, has knowledge of the operating principles of RF region measurement equipment and is able to compare the usability of different measurement equipment.

4. The student knows how to perform typical measurements of RF region magnitudes (power, frequency, impedance and noise).

**Contents:**
Fundamentals of RF and microwave techniques, components in microwave circuits, measurement instruments, measuring of power, frequency, impedance and noise, time-domain and active circuit measurements.
Mode of delivery:
Face-to-face teaching, independent design exercises and laboratory exercises.

Learning activities and teaching methods:
Lectures 24 h, design exercises 20 h, laboratory exercises 20 h, independent work 68.5 h.

Target group:
Masters students on electrical engineering

Prerequisites and co-requisites:
The recommended prerequisite is the completion of the following courses prior to enrolling for the course unit: Electronic Components and Materials, Electronic Measurement Techniques, Basics of Radio Engineering.

Recommended optional programme components:
The course is an independent entity and does not require additional studies carried out at the same time.

Recommended or required reading:

Assessment methods and criteria:
Final exam, design exercises and laboratory exercises.
Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible:
Merja Teirikangas

Working life cooperation:
No.

Other information:

521097S: Wireless Measurements, 5 cp

Validity: 01.08.2015 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Juha Saarela
Opintokohteen kielet (E): Finnish
Leikkaavuudet (E):

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<td>Wireless Measurements</td>
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<td>5211145-01</td>
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<tr>
<td>5211145-02</td>
<td>Wireless Measurements, exercise work</td>
<td>0.0 cp</td>
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ECTS Credits:
5 ECTS credits / 128h

Language of instruction:
In Finnish or in English if two or more foreign students participate.

Timing:
Period 3.

**Learning outcomes:**
1. can tell and justifying argument the benefits and challenges of using wireless measurement solutions
2. can apply the most important standards when designing wireless measurement solutions
3. can apply wireless technologies in industrial, traffic, environmental, home and healthcare measurements

**Contents:**
Basics of wireless measurement technologies and standards, wireless sensors and sensor networks, wireless building and smart home applications, wireless measurement applications in traffic, wireless environmental measurements and wireless human health monitoring.

**Mode of delivery:**
Face-to-face teaching.

**Learning activities and teaching methods:**
Lectures 22h. Seminars 6-12h depending on the number of students participating the course. The students prepare seminar presentations about contemporary topics selected by themselves or proposed by the teacher and give 10 minutes presentation to other students in the seminars.

**Target group:**
Master level students regardless of master's programme.

**Prerequisites and co-requisites:**
No prerequisites, but basics of measurements systems are recomended.

**Recommended optional programme components:**
The course replaces previous courses with same name, but different credits and code.

**Recommended or required reading:**
Lecture notes and seminar reports is Optima.

**Assessment methods and criteria:**
The course is passed with a written final exam (70 %) and a contemporary seminar (30 %). Read more about [assessment criteria](#) at the University of Oulu webpage.

**Grading:**
Grade is on numerical scale 1-5.

**Person responsible:**
Juha Saarela

**Working life cooperation:**
No.

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**521389S: Wireless Body Area Networks, 5 cp**

**Validity:** 01.08.2019 -
**Form of study:** Advanced Studies
**Type:** Course
**Unit:** Electrical Engineering DP
**Grading:** 1 - 5, pass, fail
**Teachers:** Matti Hämäläinen

**Opintokohteen kielet (E):** English

**ECTS Credits:**
5 ECTS cr

**Language of instruction:**
English
Timing:
Spring, period 3-4, will be lectured first time in 2020

Learning outcomes:
Upon completing of the course, the student will be able to
1. distinguish the basic short range communications technologies used in the wireless body area network context,
2. understand the most relevant standards,
3. differentiate and compare the key points behind these standardized technologies and what are their advantages and disadvantages.
4. understand the major characteristics and applications utilizing WBAN and
5. understand the impact of wireless channels on the WBAN system and how channel affects to the WBAN system performance.

Contents:
Introduction, existing short range radio technologies, application, WBAN architecture, sensors & actuators & wearables, WBAN protocols, signal propagation within a human, WBAN antennas, WBAN transceivers, conclusion.

Mode of delivery:
Face-to-face teaching, compulsory seminar presentation

Learning activities and teaching methods:
Lectures 28 h + compulsory seminar presentation

Target group:
1st year WCE students and M.Sc. students (i.e., 4th year in EE degree programme). Special target group is students focusing on medical information and communications technologies.

Prerequisites and co-requisites:

Recommended optional programme components:
This course is an independent entity.

Recommended or required reading:
There is no recommended textbook for this course. Course material consists of lecture notes and selected publications.

Assessment methods and criteria:
Passing the course requires an accepted final exam and given seminar presentation.

Grading:
The course unit utilizes a numerical grading scale 1-5.

Person responsible:
Matti Hämäläinen

Working life cooperation:
No

Other information:
Course will be given every second year in even years. Will be held next time in Spring 2020.

813621S: Research Methods, 5 cp

Form of study: Advanced Studies
Type: Course
Unit: Information Processing Science DP
Grading: 1 - 5, pass, fail
Opintokohteen kielet (E): English
Leikkaavuudet (E):
521146S Research Methods in Computer Science 5.0 cp

ECTS Credits:
5 ECTS credits / 133 hours of work

Language of instruction:
English

Timing:
The course is held in the spring semester, during periods 3 and 4. It is recommended to complete the course in the 1st spring semester of the Master's studies.

Learning outcomes:
Having completed the course, the student is able to explain the general principles of scientific research and the practices of scientific methodology. The student is also able to generate research problems in information processing sciences. The student is able to identify and describe the main research approaches and methods in information processing sciences, and choose the appropriate approach and method for a research problem. The student is also able to evaluate the methodological quality of a research publication. After the course the student is able to choose and apply the proper approach and method for his or her Master's thesis and find more information on the method from scientific literature.

Contents:
Introduction to general scientific principles, scientific research practices and quality of scientific publications, qualitative research approaches and selected research methods, quantitative research approaches and selected research methods, design science research and selected methods, requirements and examples of Master's theses, evaluation of research.

Mode of delivery:
Face-to-face teaching, lecture videos.

Learning activities and teaching methods:
Lectures 40 h, exercises 30 h and individual work 65 h. Learning diary is written about the lectures and exercises. Exercises include group work.

Target group:
MSc students

Prerequisites and co-requisites:
The required prerequisite is that the student has completed BSc degree as well as has basic knowledge on Software Engineering and Information Systems

Recommended or required reading:
Lecture slides and specified literature.

Assessment methods and criteria:
Accepted learning diary, active participation

Grading:
Pass or fail.

Person responsible:
Arto Lanamäki

521273S: Biosignal Processing I, 5 cp

Validity: 01.08.2005 -
Form of study: Advanced Studies
Type: Course
Unit: Computer Science and Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Tapio Seppänen
Opintokohteen kielet (E): Finnish

ECTS Credits:
5 ECTS credits / 50 hours of work

Language of instruction:
English. Examination can be taken in English or Finnish.

Timing:
The course unit is held in the autumn semester, during period 2. It is recommended to complete the course at the end of studies.

Learning outcomes:
After completing the course, student
1. knows special characteristics of the biosignals and typical signal processing methods
2. can solve small-scale problems related to biosignal analysis
3. implement small-scale software for signal processing algorithms

Contents:

Mode of delivery:
Face-to-face teaching and guided laboratory work. The laboratory work can alternatively be performed on an online system.

Learning activities and teaching methods:
Lectures 10h, Laboratory work 20h, Self-study 20h, written examination.

Target group:
Students interested in biomedical engineering, at their master's level studies.
Students of the University of Oulu.

Prerequisites and co-requisites:
The mathematic studies of the candidate degree program of computer science and engineering, or equivalent. Programming skills, especially basics of the Matlab. Basic knowledge of digital signal processing.

Recommended optional programme components:
The course is an independent entity and does not require additional studies carried out at the same time.

Recommended or required reading:
The course is based on selected chapters of the book "Biomedical Signal Analysis", R.M Rangayyan, 2nd edition (2015). + Lecture slides + Task assignment specific material.

Assessment methods and criteria:
Laboratory work is supervised by assistants who also check that the task assignments are completed properly. All task assignments are compulsory. The course ends with a written exam.
Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course unit utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible:
Tapio Seppänen

Working life cooperation:
No.
521282S: Biosignal Processing II, 5 cp

Validity: 01.08.2015 -
Form of study: Advanced Studies
Type: Course
Unit: Computer Science and Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Jukka Kortelainen
Opintokohteen kielet (E): Finnish

ECTS Credits:
5 ECTS cr

Language of instruction:
Lectures and laboratory works are given in English. The examination can be taken in Finnish or English.

Timing:
Period 4

Learning outcomes:
After completing the course, student
1. knows the special characteristics of neural signals and the typical signal processing methods related to them
2. can solve advanced problems related to the neural signal analysis

Contents:
Introduction to neural signals, artifact removal, anesthesia and natural sleep, topographic analysis and source localization, epilepsy, evoked potentials.

Mode of delivery:
Face-to-face teaching

Learning activities and teaching methods:
Lectures (8 h) and laboratory work (20 h), written exam.

Target group:
Engineering students, medical and wellness technology students, and other students interested in biomedical engineering. Students of the University of Oulu.

Prerequisites and co-requisites:
The basic engineering math courses, digital filtering, programming skills, Biosignal Processing I.

Recommended optional programme components:
-

Recommended or required reading:
The course is based on selected parts from books "EEG Signal Processing", S. Sanei and J. A. Chambers, "Bioelectrical Signal Processing in Cardiac and Neurological Applications", L. Sörnmo and P. Laguna, and "Neural Engineering", B. He (ed.) as well as lecture slides and task assignment specific material.

Assessment methods and criteria:
Laboratory work is supervised by the assistants who will also check that the task assignments are completed properly. The course ends with a written exam.
Read more about assessment criteria at the University of Oulu webpage.

Grading:
Numerical grading of the accepted exam is in the range 1-5.

Person responsible:
Jukka Kortelainen

Working life cooperation:
521467A: Digital Image Processing, 5 cp

Validity: 01.08.2012 -
Form of study: Intermediate Studies
Type: Course
Unit: Computer Science and Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Heikkilä, Janne Tapani
Opintokohteen kielet (E): Finnish
Leikkaavuudet (E):
    ay521467A   Digital Image Processing (OPEN UNI)   5.0 cp

ECTS Credits:
5 ECTS credits / 133 hours of work

Language of instruction:
Lectures in Finnish and exercises in English. Course can be passed in Finnish and English.

Timing:
Spring, period 4.

Learning outcomes:
Upon completion of the course the student:
- understands the basic theory of digital image processing and knows its main applications,
- is able to apply spatial and frequency domain and wavelet based methods in image enhancement, restoration, compression and segmentation.

Contents:

Mode of delivery:
Face-to-face teaching.

Learning activities and teaching methods:
Lectures 24 h, exercises 14 h and homework assignments 30 h. The rest is independent work.

Target group:
Computer Science and Engineering students and other Students of the University of Oulu.

Prerequisites and co-requisites:
Basic Python programming skills.

Recommended optional programme components:
In order to obtain deep understanding of the content, it is a benefit if the student has completed the mathematics courses in the computer science and engineering BSc program or otherwise has equivalent knowledge.

Recommended or required reading:
Lecture notes and exercise

Assessment methods and criteria:
The course is completed by passing the exam and homework assignments.
Read more about assessment criteria at the University of Oulu webpage.
Grading:
The course unit utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.
Person responsible:
Janne Heikkilä
Working life cooperation:
None.

521145A: Human-Computer Interaction, 5 cp

Validity: 01.08.2012 -
Form of study: Intermediate Studies
Type: Course
Unit: Computer Science and Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Simo Hosio
Opintokohteen kielet (E): English

ECTS Credits:
5 ECTS cr
Language of instruction:
In English.

Timing:
Autumn, period 2

Learning outcomes:
1. Knowledge of the Human Computer Interaction (HCI) fundamentals
2. Knowledge of evaluation techniques
3. Knowledge of prototyping techniques
4. Knowledge of how HCI can be incorporated in the software development process

Contents:
Human and computer fundamentals, design and prototyping, evaluation techniques, data collection and analysis.

Mode of delivery:
Face-to-face teaching.

Learning activities and teaching methods:
Lectures (12 h), exercises (16 h), and practical work (105 h). The course is passed with an approved practical work (several assignments). The implementation is fully English.

Target group:
Computer Science and Engineering students and other Students of the University of Oulu.

Prerequisites and co-requisites:
While no specific courses are not required, elementary programming and design skills are desired.

Recommended optional programme components:
The course is an independent entity and does not require additional studies carried out at the same time. The course involves some basic programming.

Recommended or required reading:
All necessary material will be provided by the instructor.

Assessment methods and criteria:
The assessment is project-based. Students have to complete several individual exercises throughout the semester: 1: Using questionnaires; 2: Fitts law; 3: Advanced, team-based design exercise and essay. Passing criteria: all exercises must be completed, each receiving more than 50% of the available points. Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course unit utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible:
Simo Hosio (Dr. Tech.)

Working life cooperation:
If relevant, guest lectures may be organized (optional).

521045S: Mobile Computing, 5 cp

Validity: 01.08.2018 -
Form of study: Advanced Studies
Type: Course
Unit: Computer Science and Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Denzil Teixeira Ferreira
Opintokohteen kielet (E): English
Leikkaavuudet (E):
  521046A Mobile Computing 5.0 cp
  521147S Mobile and Social Computing 5.0 cp

ECTS Credits:
5ECTS / 138 hours of work

Language of instruction:
English
Timing:
Spring, periods 3 and 4

Learning outcomes:
This course focuses on one of the core demands of industry today: deep understanding of mobile interaction, mobile computing constrains and mobile development. After this class, students will possess the:
- ability to design and prototype a mobile user interface taking into account usability aspects of interaction on smaller displays
- ability to explain and leverage the fundamental concepts of context awareness using smartphone hardware, software and human sensors
- ability to understand and implement from scratch a mobile application that leverages both usability and context to create engaging mobile experiences

Contents:
The basic concepts of mobile interface design, implementation, mobile sensor acquisition, context awareness.

Mode of delivery:
Face-to-face teaching

Learning activities and teaching methods:
5 ECTS cr = 138h of course work. Lectures (14h), in-class exercises (14h) and practical work (107h) (project, assignments).
Target group:
Computer Science and Engineering students and other students.

Prerequisites and co-requisites:
Recommended to have experience with object-oriented programming (Java, C#).

Recommended optional programme components:
The course is an independent entity and does not require additional studies carried out at the same time.

Recommended or required reading:
All necessary material will be provided by the instructor.

Assessment methods and criteria:
The assessment depends on whether the student attends or not the class. For attending students, the assessment is based on 5 laboratory exercises (which the student needs a passing grade). For non-attending students, 5 individual assignments are assigned instead of the laboratory exercises (which the student needs a passing grade). For non-attending students, there is an intermediate exam at the end of period 3 and another at the end of period 4. All students, attending or not, are peer-assessed in a team project during period 4.

Grading:
The course unit utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible:
Denzil Socrates Teixeira Ferreira

Working life cooperation:

521043S: Internet of Things, 5 cp

Validity: 01.08.2018 -
Form of study: Advanced Studies
Type: Course
Unit: Computer Science and Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Ella Peltonen
Opintokohteen kielet (E): English

ECTS Credits:
5 ECTS / 135 hours of work

Language of instruction:
English

Timing:
Spring semester during period IV

Learning outcomes:
Upon completion of the course, the student will be able to:
1. explain application areas of IoT and requirements from such application areas for IoT systems.
2. will be able to explain the state-of-the-art IoT solutions, and understand the basic technologies behind them.
3. learn the principles of the novel IoT technologies and know important directions IoT research towards.

Contents:
The basic technologies and novel applications of the Internet of Things, including networking technologies as well as Web of Things. IoT sensor technologies and sensing solutions for smart buildings.
including smart home, city, office, or campus environments, and wearables and other personal devices such as fabrication. Exercises will include hands-on programming and sensing data analytics tasks.

**Mode of delivery:**
face-to-face teaching and exercises (both individual and group work)

**Learning activities and teaching methods:**
20h lectures, 12h exercise sessions, independent studying 95 hours.

**Target group:**
M.Sc. students of Computer Science and Engineering, M. Sc. students of Ubicomp International master program. The course fits also for Statistics and Math MSc student interested in applying their knowledge into sensing and IoT data.

**Prerequisites and co-requisites:**
The Bachelor level knowledge of Computer science and engineering study programmes. Good programming skills in a chosen language.

**Recommended optional programme components:**
The course is an independent entity and does not require additional studies carried out at the same time.

**Recommended or required reading:**
Lecture hand-out, complementary reading list, and exercise material will be provided.

**Assessment methods and criteria:**
Attending lectures and exercise sessions, and returning the weekly exercises online. Read more about [assessment criteria](#) at the University of Oulu webpage.

**Grading:**
The course utilises a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

**Person responsible:**
Ella Peltonen

**Working life cooperation:**
The course may include the invited guest lectures from industry and other top EU universities.

**Other information:**
Course work space can be found from University of Oulu Moodle platform moodle.oulu.fi

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**521140S: Computer Graphics, 5 cp**

**Validity:** 01.08.2018 -

**Form of study:** Advanced Studies

**Type:** Course

**Unit:** Computer Science and Engineering DP

**Grading:** 1 - 5, pass, fail

**Teachers:** Guoying Zhao

**Opintokohteen kielet (E):** English

**Leikkaavuudet (E):**

<table>
<thead>
<tr>
<th>Code</th>
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<td>521493S</td>
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**ECTS Credits:**

5 ECTS credits

**Language of instruction:**
In English

**Timing:**
Spring, period 4.
Learning outcomes:

Upon completion of the course, the student
1. is able to specify and design 2D graphics algorithms including: line and circle drawing, polygon filling and clipping
2. is able to specify and design 3D computer graphics algorithms including transformations, viewing, hidden surface removal, shading, texture mapping and hierarchical modeling
3. is able to explain the relationship between the 2D and 3D versions of such algorithms
4. possesses the necessary basic skills to use these basic algorithms available in PyOpenGL

Contents:
The history and evolution of computer graphics; 2D graphics including: line and circle drawing, polygon filling, clipping, and 3D computer graphics algorithms including viewing transformations, shading, texture mapping and hierarchical modeling; graphics API (PyOpenGL) for implementation.

Mode of delivery:
Face to face teaching.

Learning activities and teaching methods:
Lectures 22 h / Programming lessons 6 hours / Self-study and programming assignments 107h.

Target group:
Computer Science and Engineering students and other Students of the University of Oulu.

Prerequisites and co-requisites:
Programming skills using Python; basic data structures; simple linear algebra.

Recommended optional programme components:
The course is an independent entity and does not require additional studies carried out at the same time.

Recommended or required reading:
4) Lecture notes (in English)
5) Online PyOpenGL tutorials (e.g. http://pyopengl.sourceforge.net/context/tutorials/index.html)

Assessment methods and criteria:
The assessment of the course is based on the exam (100%) with mandatory returned programming assignments.
Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course unit utilizes a numerical grading scale 1-5, zero stands for fail.

Person responsible:
Guoying Zhao, Nhat Vo, Yingyue Xu

Working life cooperation:
No

521290S: Distributed Systems, 5 cp

Validity: 01.08.2015 -
Form of study: Advanced Studies
Type: Course
Unit: Computer Science and Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Xiang Su
Opintokohteen kielet (E): Finnish
Leikkaavuudet (E):
  521266S-01  Distributed Systems, Exam  0.0 cp
  521266S-02  Distributed Systems, Exercise Work  0.0 cp
  521266S  Distributed Systems  6.0 cp

ECTS Credits:
5 ECTS cr

Language of instruction:
In English.

Timing:
Spring, period 3.

Learning outcomes:
After completing the course, the student
1. is able to explain the key principles of distributed systems
2. apply the principles in evaluating major design paradigms used in implementing distributed systems
3. solve distributed systems related problems
4. design and implement a small distributed system

Contents:
Introduction, architectures, processes, communication, naming, synchronization, consistency and replication, fault tolerance, security, case studies.

Mode of delivery:
Face-to-face.

Learning activities and teaching methods:
Lectures 22 h, exercises 16 h, project work 50 h, self-study 47 h.

Target group:
M.Sc. students (computer science and engineering) and other Students of the University of Oulu

Prerequisites and co-requisites:
None.

Recommended optional programme components:
The course is an independent entity and does not require additional studies carried out at the same time.

Recommended or required reading:

Assessment methods and criteria:
The course uses continuous assessment so that there are 2 intermediate exams. Alternatively, the course can also be passed with a final exam. The course includes a mandatory project work.

Grading:
Numerical scale 1-5; zero stands for a fail.

Person responsible:
Xiang Su

Working life cooperation:
None.

521466S: Machine Vision, 5 cp
Form of study: Advanced Studies
Type: Course
Unit: Computer Science and Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Heikkilä, Janne Tapani
Opintokohteen kielet (E): Finnish

ECTS Credits:
5 ECTS cr

Language of instruction:
English

Timing:
Spring, period 3.

Learning outcomes:
Upon completion of the course the student
1. understands the fundamentals of image acquisition, representation and modeling
2. can utilize elementary methods of machine vision for image recognition problems
3. can use 2D transformations in model fitting and image registration
4. can explain the basics of 3D imaging and reconstruction

Contents:

Mode of delivery:
Face-to-face teaching, homework assignments.

Learning activities and teaching methods:
Lectures (20 h), exercises (16 h) and programming assignments (30 h), self-studying (67 h).

Target group:
Computer Science and Engineering students and other Students of the University of Oulu.

Prerequisites and co-requisites:
521467A Digital Image Processing or an equivalent course, basic Python programming skills.

Recommended optional programme components:
521289S Machine Learning. This course provides complementary knowledge on machine learning methods needed in machine vision.

Recommended or required reading:

Assessment methods and criteria:
The course is passed with final exam and accepted homework assignments. Read more about assessment criteria at the University of Oulu webpage.

Grading:
Numerical grading scale 1-5. Zero stands for a fail.

Person responsible:
Janne Heikkilä
**Working life cooperation:**

No.

**521156S: Towards Data Mining, 5 cp**

- **Validity:** 01.08.2017 -
- **Form of study:** Advanced Studies
- **Type:** Course
- **Unit:** Computer Science and Engineering DP
- **Grading:** 1 - 5, pass, fail
- **Teachers:** Satu Tamminen
- **Opintokohteen kielet (E):** Finnish

**ECTS Credits:**

5 ECTS credits

**Language of instruction:**

Finnish or English

**Timing:**

Autumn, period I.

**Learning outcomes:**

Student can recognize the type of the data before further analysis and the required preprocessing. The concrete learning outcomes are:
1. Student can design and implement the data gathering
2. Student can combine data from different sources
3. Student can normalize and transform data, and handle missing or incorrect data.
4. Student can ensure the generalizability of the results.

**Contents:**

Course provides good ability to start Master's Thesis or graduate studies. Topics at the course include data mining process in general level, data gathering and different data types, quality and reliability of the data, data preparation including the processing of missing values, outliers, and privacy issues, combination of signals from several sources, utilization of data bases in data mining process, and normalization and transformation of data and interdependence of the observations and their distributions. Additionally, topics concerning the generality of the results are covered, as well as, the principles of data division, for example, train-test-validate, cross-validation and leave-one-out methods.

**Mode of delivery:**

Lectures, independent work, group work

**Learning activities and teaching methods:**

16 h lectures, 16 h exercises, independent studying.

**Target group:**

The course is suitable for Master level students in Computer science and engineering study programmes, for minor subject studies or for doctoral students.

**Prerequisites and co-requisites:**

031021P Probability and Mathematical Statistics or similar

**Recommended optional programme components:**

The course is an independent entity and does not require additional studies carried out at the same time.

**Recommended or required reading:**

Lecture hand-out and exercise material will be provided. The course book will be announced in the beginning of the course. The material is mostly in English.
Assessment methods and criteria:
Weekly pre-lecture assignment + exercise submissions, and final exam. Half of the grade will be based on the submissions and half on the final exam. Read more about assessment criteria at the University of Oulu webpage.

Grading:
Numerical grading scale 1-5; zero stands for a fail.

Person responsible:
Tamminen Satu

Working life cooperation:
-

Other information:
-

521260S: Programmable Web Project, 5 cp

Validity: 01.08.2006 -
Form of study: Advanced Studies
Type: Course
Unit: Computer Science and Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Ivan Sanchez Milara
Opintokohteen kielet (E): English
Leikkaavuudet (E):
ay521260S Programmable Web Project (OPEN UNI) 5.0 cp

Status:
The course is mandatory for International Master's Programme in Computer Science and Engineering and Master's Programme in Computer Science and Engineering. It is optional for other degree and master programmes.

ECTS Credits:
5 ECTS cr

Language of instruction:
In English.

Timing:
Spring, periods 3-4.

Learning outcomes:
Upon completion of this course, students:
- understand what a Web API is and learn different Web API architectures.
- understand the concept of hypermedia and how it is used to build Web APIs.
- are able to design and implement a Web API following REST architectural style principles using existing web frameworks.
- are able to write unit and functional tests to inspect their APIs.
- are able to document their Web APIs using adequate software tools.
- are able to implement simple software applications that make use of the APIs.

Contents:
RESTful Web API, Hypermedia, RESTful asiakkaat.

Mode of delivery:
Web-based teaching and face-to-face teaching.
**Learning activities and teaching methods:**
Lectures 4 h, guided laboratory work 15 h, the rest as self-study and group work. Each group implements programs and writes a report.

**Target group:**
M.Sc. level students of Computer Science and Engineering; other students of the university of Oulu are accepted if there is enough space in the classes.

**Prerequisites and co-requisites:**
Elementary programming (521141P) or equivalent Python programming skills. Applied computing project I is recommended.

**Recommended optional programme components:**
The course is an independent entity and does not require additional studies carried out at the same time.

**Recommended or required reading:**

**Assessment methods and criteria:**
This course unit utilizes continuous assessment. The project work is divided in different deadlines that students must meet to pass the course. Each deadline will be assessed after completion. Read more about [assessment criteria](#) at the University of Oulu webpage.

**Grading:**
The course unit utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

**Person responsible:**
Ivan Sanchez Milara

**Working life cooperation:**
None.

**Other information:**
This course replaces the course “521260S Representing structured information”.

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521479S: Software Project, 7 cp

**Form of study:** Advanced Studies

**Type:** Course

**Unit:** Computer Science and Engineering DP

**Grading:** 1 - 5, pass, fail

**Teachers:** Christian Wieser

**Opintokohteen kielet (E):** English

**ECTS Credits:**
7

**Language of instruction:**
Finnish/English, material available in English.

**Timing:**
Autumn, periods 1-2.

**Learning outcomes:**
After completing the course, students have demonstrated their capabilities to design, develop and test real-life software. Further, they have shown their proficiency in professionally documenting their work during the assignment.
Contents:
Phases of software engineering process: requirement gathering, analysis, design, implementation, testing, (maintenance). Project-work, starting a project, project management, working with external parties, project documentation. Project related implementation techniques and tools, software documentation.

Mode of delivery:
Face-to-face and independent studies.

Learning activities and teaching methods:
Working methods: The course is done in groups of 3-4 students. The clients are typically various companies and societies. Project progress is supervised in formal reviews, where the project teams present their work as it reaches the milestones: the software requirement specification, the project plan, the software design specification, an operational prototype demonstration, the test documentation, and finally the functional software demonstration and release. In addition to formal reviews the project work is coordinated with steering group meetings. The work environment and development tools vary between projects. The number of students that can attend the course is limited. Lectures 10 h, design project in period 4-6 180 h.

Target group:
Computer Science and Engineering students and other Students of the University of Oulu.

Prerequisites and co-requisites:

Recommended optional programme components:
The course is an independent entity and does not require additional studies carried out at the same time.

Recommended or required reading:

Assessment methods and criteria:
Project work and documentation. Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course unit utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible:
Christian Wieser

Working life cooperation:
-

Other information:
-

521283S: Big Data Processing and Applications, 5 cp

Validity: 01.08.2015 -

Form of study: Advanced Studies

Type: Course

Unit: Computer Science and Engineering DP

Grading: 1 - 5, pass, fail

Teachers: Ekaterina Gilman

Opintokohteen kielet (E): English
ECTS Credits:
5 ECTS credits

Language of instruction:
English

Timing:
Period IV. It is recommended that the course is taken on the fourth year Spring.

Learning outcomes:
Upon completion of the course, the student:
1. is able to explain the big data phenomenon, its challenges and opportunities.
2. is able to explain the requirements and common principles for data intensive systems design and implementation, and evaluate the benefits, risks and restrictions of available solutions.
3. can explain the principles of big data management and processing technologies and utilize them on a basic level.

Contents:
General introduction into big data, namely: big data fundamentals, data storage, batch and stream data processing, data analysis, privacy and security, big data use cases.

Mode of delivery:
Face-to-face teaching, independent and group work

Learning activities and teaching methods:
Lectures, exercises, seminars, independent and group work

Target group:
M.Sc. students (computer science and engineering) and other Students of the University of Oulu

Prerequisites and co-requisites:
The Bachelor level studies of Computer science and engineering study programmes or respective knowledge.

Recommended optional programme components:

Recommended or required reading:
Lecture slides and exercise material will be provided. Each lecture will include the refernce list for recommended reading. Instructions to necessary installations will be given.

Assessment methods and criteria:
This course assesses students continuously by the completion of small project work, seminar presentations and short reports on a selected topic (group work). Answering two quizzes during the course is optional and provides additional points for final grade. To pass the course, it is enough to get 50 % of available points. No exam.
Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

Person responsible:
Ekaterina Gilman

Working life cooperation:
The course includes also invited lectures from industry.

521158S: Natural Language Processing and Text Mining, 5 cp

Validity: 01.08.2017 -
Form of study: Advanced Studies
Type: Course
Unit: Computer Science and Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Mourad Oussalah
Opintokohteen kielet (E): English

ECTS Credits:
5 ECTS credits / 120 hours of works

Language of instruction:
English

Timing:
Period 2. It is recommended to complete the course at the end of period 2

Learning outcomes:
Upon completing the course, the student is expected to i) comprehend, design and implement basic (online) text retrieval and query systems; ii) account for linguistic aspects and perform word sense disambiguation; iii) perform basic (statistical) inferences using corpus; iv) manipulate (statistical) language modelling toolkits, online lexical databases and various natural language processing tools.

Contents:
Foundation of text retrieval systems, Lexical ontologies, word sense disambiguation, Text categorization, Corpus-based inferences and Natural Language Processing tools

Mode of delivery:
Face- to-face teaching and laboratory sessions

Learning activities and teaching methods:
Lectures (24 h), tutorial/laboratory sessions (16h), seminar (6h) and practical work. The course is passed with an approved practical work and class test. The implementation is fully in English.

Target group:
students with (moderate to advanced) programming skills in Python

Prerequisites and co-requisites:
Programming skills (preferably) in Python

Recommended optional programme components:
The course is an independent entity and does not require additional studies carried out at the same time

Recommended or required reading:

Assessment methods and criteria:
One class test (30%) in the middle of the term + Project work (70%)
Read more about assessment criteria at the University of Oulu webpage.

Grading:
1-5

Person responsible:
Mourad Oussalah

Working life cooperation:
-
521289S: Machine Learning, 5 cp

Validity: 01.08.2015 -
Form of study: Advanced Studies
Type: Course
Unit: Computer Science and Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Tapio Seppänen
Opintokohteen kielet (E): Finnish
Leikkaavuudet (E):
  521497S-01 Pattern Recognition and Neural Networks, Exam 0.0 cp
  521497S-02 Pattern Recognition and Neural Networks; Exercise Work 0.0 cp
  521497S Pattern Recognition and Neural Networks 5.0 cp

ECTS Credits:
5 ECTS cr

Language of instruction:
English. Examination can be taken in English or Finnish.

Timing:
The course unit is held in the spring semester, during period III. It is recommended to complete the course at the end of studies.

Learning outcomes:
After completing the course, student
1. can design simple optimal classifiers from the basic theory and assess their performance.
2. can explain the Bayesian decision theory and apply it to derive minimum error classifiers and minimum cost classifiers.
3. can apply the basics of gradient search method to design a linear discriminant function.
4. can apply regression techniques to practical machine learning problems.

Contents:

Mode of delivery:
Face-to-face teaching, guided laboratory work and independent assignment.

Learning activities and teaching methods:
Lectures 16 h, Laboratory work 16 h, Exercise 16 h and Self-study the rest (Independent task assignment, written examination).

Target group:
Students who are interested in data analysis technology. Students of the University of Oulu.

Prerequisites and co-requisites:
The mathematic studies of the candidate degree program of computer science and engineering, or equivalent. Programming skills, especially basics of the Matlab.

Recommended optional programme components:
The course is an independent entity and does not require additional studies carried out at the same time.

Recommended or required reading:

Assessment methods and criteria:
Laboratory work is supervised by assistants who also check that the task assignments are completed properly. The independent task assignment is graded. The course ends with a written exam. Read more about assessment criteria at the University of Oulu webpage.

**Grading:**
The course unit utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail. The final grade is established by weighing the written exam by 2/3 and the task assignment by 1/3.

**Person responsible:**
Tapio Seppänen

**Working life cooperation:**
No

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**521161S: Multi-Modal Data Fusion, 5 cp**

**Validity:** 01.08.2017 -

**Form of study:** Advanced Studies

**Type:** Course

**Unit:** Computer Science and Engineering DP

**Grading:** 1 - 5, pass, fail

**Opintokohteen kielet (E):** English

**ECTS Credits:**
5 ECTS / 135 hours of work

**Language of instruction:**
English

**Timing:**
Period 2

**Learning outcomes:**
Upon completion the student should be able to understand the problem of combining data (such as images and audios) of different natures and coming from different sources. The student should be able to implement basic solutions towards the accomplishment of a given task requiring the integration and combination of data.

**Contents:**
This course will provide a comprehensive introduction to the concepts and ideas of multi-sensor data fusion. The course will be illustrated with many real-life examples taken from a diverse range of applications. The course will be self-contained as much as possible (no previous knowledge of multisensor data fusion is assumed). Basic knowledge on related topics like image processing and signal processing will be a plus.
The course will discuss the following topics:
Introduction
Sensors
Architecture
Common Representational Format
Spatial Alignment
Temporal Alignment
Semantic Alignment
Radiometric Normalization
Bayesian Inference
Parameter Estimation
Robust Statistics
Sequential Bayesian Inference
Bayesian Decision Theory
Ensemble Learning
Sensor Management

**Mode of delivery:**
The course will be based on a combination of lectures (face-to-face teaching), home exercises and a final project.

**Learning activities and teaching methods:**
Face-to-face teaching: 20 h, home exercises: 80 h, final project: 35h

**Target group:**
Computer Science and Engineering, Ubiquitous Computing (M.Sc level, study years 4-5).

**Prerequisites and co-requisites:**
The course will be self-contained as much as possible (no previous knowledge is assumed). Basic knowledge on related topics like image processing and signal processing will be a plus.

**Recommended optional programme components:**
-

**Recommended or required reading:**

**Assessment methods and criteria:**
To pass the course, the student should retrain the exercises, complete a final programming project and pass an exam.
Read more about [assessment criteria](#) at the University of Oulu webpage.

**Grading:**
The course will utilize a numerical grading scale 1-5.

**Person responsible:**
Abdenour Hadid (lecturer), Mohammad Tavakolian (Assistant)

**Working life cooperation:**
The course includes one or two guest lectures from experts with practical experience.

**Other information:**
521161S Multi-modal Data Fusion, which is a compulsory study for the Master's students (Specialization Options: Artificial Intelligence, 2017, 2018, 2019 starting), will not be held this year (future info for course not be available). The course can be replaced by an optional course.

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521285S: Affective Computing, 5 cp

**Validity:** 01.08.2015 -

**Form of study:** Advanced Studies

**Type:** Course

**Unit:** Computer Science and Engineering DP

**Grading:** 1 - 5, pass, fail

**Teachers:** Guoying Zhao

**Opintokohteen kielet (E):** English

**ECTS Credits:**
5 ECTS credits

**Language of instruction:**
In English

**Timing:**
Fall, periods 1

**Learning outcomes:**
After completing the course, student
1. is able to explain the emotion theory and modeling
2. is able to implement algorithms for emotion recognition from visual and audio signals, and the fusion of multi-modalities
3. has the ideas of wide applications of affective computing

**Contents:**
The history and evolution of affective computing; psychological study about emotion theory and modeling; emotion recognition from different modalities: facial expression, speech, fusion of multi-modalities; crowdsourcing study; synthesis of emotional behaviors; emotion applications.

**Mode of delivery:**
Face to face teaching

**Learning activities and teaching methods:**
The course consists of lectures and exercises. The final grade is based on the points from exam while there are several mandatory exercises.

**Target group:**
Computer Science and Engineering students and other Students of the University of Oulu.

**Prerequisites and co-requisites:**
A prior programming knowledge with Python, possibly the bachelor level mathematical studies and/or some lower level intermediate studies (e.g. computer engineering or artificial intelligence courses). The recommended optional studies include the advanced level studies e.g. the pattern recognition and neural networks and/or computer vision courses.

**Recommended optional programme components:**

**Recommended or required reading:**
All necessary material will be provided by the instructor.

**Assessment methods and criteria:**
The assessment of the course is based on the exam (100%) with mandatory exercises. Read more about assessment criteria at the University of Oulu webpage.

**Grading:**
The course unit utilizes a numerical grading scale 1-5, zero stands for fail.

**Person responsible:**
Guoying Zhao, Henglin Shi, Yante Li

**Working life cooperation:**
No

**521153S: Deep Learning, 5 cp**

**Validity:** 01.08.2019 -

**Form of study:** Advanced Studies

**Type:** Course

**Unit:** Computer Science and Engineering DP

**Grading:** 1 - 5, pass, fail

**Teachers:** Li Liu

**Opintokohteen kielet (E):** English

**ECTS Credits:**
5ECTS credits/135 hours of work

**Language of instruction:**
English

**Timing:**
autumn, period 2

**Learning outcomes:**
Upon completion of the course, the students will be able to: learn the theories, models, algorithms, implementation and recent progress of deep learning; obtain empirical experience on training deep neural networks; know applications of deep learning to typical computer vision problems such as object detection and segmentation and know important directions deep learning research towards; learn to implement, train and debug their own neural networks in TPyTorch.

**Contents:**
Topics covered will include linear classifiers, multilayer neural networks, back propagation and stochastic gradient descent, convolutional neural networks, recurrent neural networks, and generative adversarial networks. Applications of deep learning to typical computer vision problems such as object detection and segmentation will also be included.

**Mode of delivery:**
Face-to-face teaching

**Learning activities and teaching methods:**
20h lectures, 12h exercise sessions, independent studying 95 hours.

**Target group:**
B.Sc. and M.Sc. students of Computer Science and Engineering. The course fits also for Statistics and Math M.Sc. students interested in learning deep learning techniques.

**Prerequisites and co-requisites:**
The Bachelor level knowledge of Computer science and engineering study programmes. Good programming skills in a chosen language.

**Recommended optional programme components:**
The course is an independent entity and does not require additional studies carried out at the same time.

**Recommended or required reading:**
Lecture hand-out, complementary reading list, and exercise material will be provided.

**Assessment methods and criteria:**
Attending lectures and exercise sessions, and returning the weekly exercises and final project. Read more about assessment criteria at the University of Oulu webpage.

**Grading:**
The course utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

**Person responsible:**
Li Liu

**Working life cooperation:**
The course may include the invited guest lectures from industry and other top universities.

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**521155S: Computer Security, 5 cp**

**Validity:** 01.08.2017 -

**Form of study:** Advanced Studies

**Type:** Course

**Unit:** Computer Science and Engineering DP

**Grading:** 1 - 5, pass, fail
Teachers: Juha Röning, Teemu Tokola

Opintokohteen kielet (E): English

ECTS Credits:
5 ECTS cr / 135 hours of work

Language of instruction:
English

Timing:
Autumn Semester, period 1.

Learning outcomes:
Upon completion of this course, students know and understand the basics and advanced concepts of the following key areas of the course and cybersecurity, know key terminology and can write about the topics clearly and with justifications:
- Finding software errors and vulnerabilities with fuzz-testing
- Vulnerabilities and testing of websites and communication protocols
- Principles of hardware level vulnerabilities and their testing and detection
- Principles of different software vulnerabilities, malware programs and shellcode and memory protection measures
- Cyber crime, cyber forensics and botnets
- Mobile and IoT security and manufacturing security, testing and protection measures

Additionally, students that have attained grades 2 or 3 have demonstrated technical capacity to perform practical work relevant to the course key areas. Students that have attained grades 4 or 5 have additionally demonstrated capacity for independent, ambitious work on the key areas working on advanced and challenging security research questions.

Contents:
The course covers the essential aspects of computer security and computer security research in theory and through practical examples.

Mode of delivery:
Contact teaching and independent work

Learning activities and teaching methods:
14 hours of lectures ja 28 hours of laboratory exercises, rest independent work alone or in groups.

Target group:
The course is intended for computer engineering masters students and additionally to any student interested in computer security that has the sufficient technical background to complete the course exercises.

Prerequisites and co-requisites:
As prior knowledge students should have a basic understanding of how computers, operating systems and the Internet work and basic skills in programming. Examples of suitable courses to cover these fundamentals are Operating Systems 521453A, Introduction to Programming 521141P and Computer Engineering 521267A.

Recommended optional programme components:
The course is an independent entity.

Recommended or required reading:
-

Assessment methods and criteria:
Grading of the course is made based on the course practical assignments.

Grading:
Numerical grade 0-5, where 0 stands for a fail.

**Person responsible:**
Juha Röning, Teemu Tokola

**Working life cooperation:**
-

**521495A: Artificial Intelligence, 5 cp**

- **Validity:** 01.08.2012 -
- **Form of study:** Intermediate Studies
- **Type:** Course
- **Unit:** Computer Science and Engineering DP
- **Grading:** 1 - 5, pass, fail
- **Opintokohteen kielet (E):** English
- **Leikkaavuudet (E):**
  - ay521495A  Artificial Intellig (OPEN UNI)  5.0 cp

**ECTS Credits:**
5 ECTS cr

**Language of instruction:**
English

**Timing:**
Period 3.

**Learning outcomes:**
1. is able to identify the types of problems that can be solved using methods of artificial intelligence.
2. knows the basic concepts of intelligent agents, the common search methods used in artificial intelligence, logic based reasoning and applying planning techniques to problems of artificial intelligence.
3. can also apply simple methods to reasoning under uncertainty and machine learning from observation.
4. In addition the student will be able to implement the most common search methods.

**Contents:**

**Mode of delivery:**
Face-to-face teaching.

**Learning activities and teaching methods:**
28 hours of lectures and a programming exercise (approximately 25 hours) during period 3, the rest as independent work.

**Target group:**
Computer Science and Engineering students and other Students of the University of Oulu.

**Prerequisites and co-requisites:**
Programming skills.

**Recommended optional programme components:**
The course is an independent entity and does not require additional studies carried out at the same time.
Recommended or required reading:
The course material is based on the Artificial Intelligence course of Berkely University and the book "Artificial Intelligence, A Modern Approach" by Russell & Norvig.
1) http://ai.berkeley.edu/home.html

Assessment methods and criteria:
The course is passed with a final exam and a passed programming exercise. Read more about assessment criteria at the University of Oulu webpage.

Grading:
1-5 / fail.

Person responsible:
Pekka Sangi and Jaakko Suutala (lecturer)
Mohammad Tavakolian (assistant)

Working life cooperation:
-

Other information:
-

521042S: Creative Design, 5 cp

Validity: 01.08.2018 -
Form of study: Advanced Studies
Type: Course
Unit: Computer Science and Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Georgi Georgiev
Opintokohteen kielet (E): English

ECTS Credits:
5 ECTS credits/ 135 hours of work

Language of instruction:
English

Timing:
Period 1

Learning outcomes:
Upon completion of this course, students are able to:
- Understand and apply in practice basic creative problem-solving and design thinking approaches.
- Systematically ideate and implement creative solutions to a problem, both independently and within a team.
- Apply creative design thinking and low-resolution prototyping, with emphasis on empathy, iterative strategies, and interactions.

Contents:
The course teaches students of (1) Creative problem-solving; (2) Design thinking and low-resolution prototyping; (3) Teamwork problem-solving; (4) Systematic ideation approaches.

Mode of delivery:
Face-to-face teaching, teamwork/individual work, and independent studying.

Learning activities and teaching methods:
Lectures 21h / Individual work 124h. There are TA hours each week where guidance is available.
Target group:
Primary target group is first year master’s level students of computer science and engineering with the applied computing orientation.

Prerequisites and co-requisites:
There are no prerequisites or co-requisites.

Recommended optional programme components:

Recommended or required reading:
All necessary material will be provided by the instructor.

Assessment methods and criteria:
20% attendance of 7 lecture-exercises; 40% exercise completion and performance; 40% individual project outcome.

Grading:
The course utilizes a numerical grading scale 1-5. In the numerical scale zero stands for fail.

Person responsible:
Georgi Georgiev

Working life cooperation:

521288S: Multiprocessor Programming, 5 cp

Validity: 01.08.2015 -
Form of study: Advanced Studies
Type: Course
Unit: Computer Science and Engineering DP
Grading: 1 - 5, pass, fail
Opintokohteen kielet (E): Finnish
Leikkaavuudet (E):
   521280S   DSP Laboratory Work   5.0 cp

ECTS Credits:
5 ECTS credits / 135 hours of work
Language of instruction:
English
Timing:
Spring semester, periods 3-4
Learning outcomes:
Upon completion of the course, the student:
1. has basic understanding of multiprocessor architectures and heterogeneous computing,
2. has basic understanding on how to design and implement algorithms for heterogeneous platforms,
3. understands the possible challenges and shortcomings related to the current heterogeneous systems,
4. is able to use the OpenCL framework for designing, implementing and optimizing signal processing algorithms for heterogeneous platforms

Contents:
Algorithm design, general purpose computing on graphics processing units, heterogeneous computing, OpenCL programming and optimization

**Mode of delivery:**
Opening lecture and independent exercise project, which is divided into smaller sub-entities. The exercise project is performed using both desktop and mobile platforms. After each sub-entity, a short seminar is held where the students discuss their results and possible ways to optimize the performance of their implementation.

**Learning activities and teaching methods:**
Opening lecture (2h), seminars (8h) and independent exercise project (125h).

**Target group:**
Computer Science and Engineering students + other Students of the University of Oulu. This is an advanced-level course intended for masters-level students and post-graduate students, especially to those who are specializing into signal processing.

**Prerequisites and co-requisites:**
Matrix Algebra 031078P, Elementary programming 521141P, Computer Systems 521286A, Digital Filters 521337A

**Recommended optional programme components:**
The course is an independent entity and does not require additional studies carried out at the same time.

**Recommended or required reading:**
-

**Assessment methods and criteria:**
Students complete the course exercises after the attending to the opening lecture in groups of two students. Assessment is based on the quality of the completed exercises and exercise reports. More detailed information on assessment will be announced at the beginning of the course. Read more about assessment criteria at the University of Oulu webpage.

**Grading:**
Numerical grading scale 1-5; zero stands for a fail.

**Person responsible:**
Mehdi Safarpour

**Working life cooperation:**
No

**Other information:**
-

**521281S: Application Specific Signal Processors, 5 cp**

**Validity:** 01.08.2012 -

**Form of study:** Advanced Studies

**Type:** Course

**Unit:** Computer Science and Engineering DP

**Grading:** 1 - 5, pass, fail

**Teachers:** Olli Silven

**Opintokohteen kielet (E):** English

**ECTS Credits:**
5 ECTS credits / 135 hours of work
Language of instruction:
English.

Timing:
Autumn, period 1

Learning outcomes:
After completing the course, student
1. Can distinguish the main types of signal processors
2. Can design basic customized transport triggered architecture processors
3. Is capable of assembling a signal processor out of basic entities
4. Can match the processor performance and the application requirements
5. Applies the TTA codesign environment and Altera's FPGA tools to synthesize a system

Contents:
Examples of modern signal processing applications, main types of signal processors, parallel signal processing, transport triggered architectures, algorithm-architecture matching, TCE design environment and Altera FPGA tools.

Mode of delivery:
Lectures, exercises, independent work, group work.

Learning activities and teaching methods:
Lectures 12h (participation mandatory); Instructed labs 12h. Independent work 111h

Target group:
Computer Science and Engineering students + other Students of the University of Oulu. This is an advanced-level course intended for masters-level students and post-graduate students, especially to those who are specializing into signal processing.

Prerequisites and co-requisites:
521267A Computer Engineering or 521286A Computer Systems (8 ECTS cr) or 521287A Introduction to Computer Systems (5 ECTS cr) and 521337A digital filters, programming skills

Recommended optional programme components:
The course is an independent entity and does not require additional studies carried out at the same time.

Recommended or required reading:
Handouts.

Assessment methods and criteria:
Participation in mandatory classes and approved lab exercises and project works. Read more about assessment criteria at the University of Oulu webpage.

Grading:
Numerical grading scale 1-5; zero stands for a fail.

Person responsible:
Mehdi Safarpour

Working life cooperation:
No.

521423S: Embedded System Project, 5 cp

Form of study: Advanced Studies
Type: Course
Unit: Computer Science and Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Juha Röning
ECTS Credits:
5

Language of instruction:
Lecturing in Finnish, material available in English

Timing:
Spring, periods 3-4.

Learning outcomes:
1. After passing the course, the student is familiar with the design process of an embedded system, from specifying the application leading to the requirement specification for the device, and then to having produced a functional prototype of the defined system.
2. The student is more familiar with the roles of the client and the system developer during the requirement specification, and the role of the iterations as a part of the whole design process. From the specifications, the student is familiar with the process of choosing the suitable hardware components, circuit design and implementation. In the end, the student is also able to know the factors arising from the SW/HW partitioning process of the actual implementation, and the concept of SW/HW dualism. The student can then better utilize the basic development tools used for embedded system design and recognize their possible advantages and disadvantages.
3. The student is more familiar with the testing and problem solving methodology related to the prototype implementation of an embedded system, to have the prototype working correctly according to the specifications.

Contents:
The embedded system design process, from initial specification to implementation of a first functional prototype and demonstrating its functionality in practice. The application can be suggested by the student group, or chosen from the topics suggested by the course organizers. During the work, the students familiarize themselves with modern design tools and methodologies related to embedded system design (according to the microcontroller the student group has chosen to utilize in their work). Most commonly used platforms on the course include STM, Atmel and Microchip based platforms.

Mode of delivery:
Lectures, face-to-face tutoring and self-study.

Learning activities and teaching methods:
The course is run as a project work in groups of three with progress follow-up reporting meetings. Lectures 10 h, laboratory exercise in period 3-4 120 h.

Target group:
Computer Science and Engineering students and other Students of the University of Oulu.

Prerequisites and co-requisites:
811122P Introduction to Programming
521412A Digital Techniques I
Also recommended; 521275A Embedded Software Project, 521432A Electronics Design I.

Recommended optional programme components:
The course is an independent entity and does not require additional studies carried out at the same time.

Recommended or required reading:
-

Assessment methods and criteria:
Project work.
Read more about assessment criteria at the University of Oulu webpage.

Grading:
The course unit utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.
**Person responsible:**
Juha Röning

**Working life cooperation:**
None.

**521318S: Modern Topics in Telecommunications and Radio Engineering, 3 - 7 cp**

- **Form of study:** Advanced Studies
- **Type:** Course
- **Unit:** Electrical Engineering DP
- **Grading:** 1 - 5, pass, fail
- **Teachers:** Matti Latva-aho, Jari Iinatti
- **Opintokohteen kielet (E):** English
- **Voidaan suorittaa useasti (E):** Yes

**ECTS Credits:**
3-7

**Language of instruction:**
English

**Timing:**
Fall & Spring, periods 1-4

**Learning outcomes:**
After completing the course the student understand and is able to analyze basic principles of the topic which has been presented in the course. The final outcomes will be defined based on the contents.

**Objective:** Depending on each year's topic, the course gives either an overview or deepens knowledge of actual topics and applications on radio techniques and telecommunications. The course comprises varying topical subjects, applications, research areas. Depending on the subject, the course may comprise a seminar of essays that practices a student for spontaneously acquiring information, improves readiness for making a master's thesis and readiness for performing in front of an audience.

**Contents:**
Varies yearly based on actual topics in telecommunications and radio engineering.

**Mode of delivery:**
Face-to-face teaching

**Learning activities and teaching methods:**
Lectures and/or exercises and/or design exercise and/or seminars depending on the topic of the year. The start and implementation of the course will be informed separately. The course can be given several times with different contents during the academic year and it can be included into the degree several times.

**Target group:**
1st and 2nd year M.Sc. and WCE students.

**Prerequisites and co-requisites:**
Will be defined based on the contents.

**Recommended optional programme components:**
-

**Recommended or required reading:**
Will be defined in the beginning of the course.

**Assessment methods and criteria:**
Depends on the working methods.
Grading:
The course unit utilizes a numerical grading scale 1-5. Read more about assessment criteria at the University of Oulu webpage.

Person responsible:
Matti Latva-aho, Jari Iinatti

Working life cooperation:
-

Other information:
-

521322S: Telecommunication Engineering Project, 5 cp

Validity: 01.08.2015 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Markus Berg, Saarnisaari, Harri Tapani

Opintokohteen kielet (E): Finnish
Leikkaavuudet (E):
521387S Telecommunication Engineering Project 4.0 cp

ECTS Credits:
5 ECTS credits / 135 hours of work

Language of instruction:
English/Finnish

Timing:
Fall or Spring, periods 1-4

Learning outcomes:
After completing the course student can
1. depending on the work subject, either solve, design, construct, measure, simulate, test or analyze limited telecommunication and radio system and sub-system problems.
2. apply the technical knowledge acquired from advanced sources into practical engineering tasks.
3. document technical and scientific results.

Contents:
Varies depending on the topic.

Mode of delivery:
Independent work.
If you would like to take the course, you can contact the course person responsible.

Learning activities and teaching methods:
The design exercise is done in a group of one or two students depending of work's difficulty. The design exercise can be simulation or implementation work. The work can be defined by the Department of Communications Engineering or by industry. In the later case a proposal must be submitted to the teacher before beginning of the work. Also, student must meet the schedule and deadlines given by a supervisor before starting the work. In preparing the work report document the writing instructions of DCE department's diploma thesis must be followed.

Target group:
1st or 2nd year M.Sc. and WCE students

**Prerequisites and co-requisites:**
Depending on the subject: advanced courses dealing with telecommunication systems, digital communications, digital signal processing or/and radio engineering.

**Recommended optional programme components:**
The course is an independent entity and does not require additional studies carried out at the same time.

**Recommended or required reading:**
Varies depending on the topic.

**Assessment methods and criteria:**
Written work report.
Read more about [assessment criteria](#) at the University of Oulu webpage.

**Grading:**
The course utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.

**Person responsible:**
Markus Berg / Harri Saarnisaari

**Working life cooperation:**
No

**Other information:**
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521300S: Electronics Design and Construction Exercise, 6 cp

**Validity:** 01.08.2015 -
**Form of study:** Advanced Studies
**Type:** Course
**Unit:** Electrical Engineering DP
**Grading:** 1 - 5, pass, fail
**Teachers:** Kari Määttä
**Opintokohteen kielet (E):** Finnish
**Leikkaavuudet (E):**

- 521441S  Electronics Design and Construction Exercise  6.5 cp

**ECTS Credits:**
6

**Language of instruction:**
Finnish, English

**Timing:**
Periods 1-4

**Learning outcomes:**
1 is able to carry out all the stages needed to develop an electronic circuit or device starting from independent creation and design work to realization, testing and technical documentation.
2 is able to use independently without any help professional methods, software packages, measurement devices and tools.
3 Objective: To familiarize the student with independent electrical circuit and system design and with the methods and tools used in the design process. The course prepares the student for the diploma work in the area of circuits and system design.

**Contents:**
Design and construction of an electronic device or a part of a device according to the given specification. The task can be part of an industrial research or a product design project or part of the research project going on in Electronics or other laboratory. The subject of the work can be own suggestion of the student or a pre-selected course subject, which enables comprehensive training of skills needed for the design of a modern electronic device.

**Mode of delivery:**
Independent work.

**Learning activities and teaching methods:**
Independent design and construction work 180h

**Target group:**
Primarily in electrical engineering students. Other University of Oulu students can complete the course

**Prerequisites and co-requisites:**
Student must have passed following courses: Analogue Electronics I-II, Digital Techniques I-II, Electronic System Design and Filter Theory.

**Recommended optional programme components:**
The course is an independent entity and does not require other studies carried out at the same time.

**Recommended or required reading:**
Not defined

**Assessment methods and criteria:**
The task can be carried out by a student or by a team of two students. The grade will be decided on the basis of the statement of the instructor, realization of the device and the report provided by the student. Read more about assessment criteria at the University of Oulu webpage.

**Grading:**
The course unit utilizes a numerical grading scale 0 - 5. In the numerical scale 0 stands for a fail.

**Person responsible:**
Kari Määttä

**Working life cooperation:**
No

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**521016A: Advanced Practical Training, 3 cp**

**Validity:** 01.08.2005 -

**Form of study:** Intermediate Studies

**Type:** Practical training

**Unit:** Electrical Engineering DP

**Grading:** 1 - 5, pass, fail

**Teachers:** Hannu Sorvoja

**Opintokohteen kielet (E):** Finnish

**Leikkaavuudet (E):**
- 521026S Advanced practical training 5.0 cp

**ECTS Credits:**
3

**Language of instruction:**
Finnish/English

**Timing:**
1-4

**Learning outcomes:**
After advanced practical training the student can describe one possible future job, or another kind of position in an already familiar working environment. The student can identify problems in the working environment and solve them. The student can apply theoretical knowledge acquired in the studies to practical tasks. The student can identify roles of a diploma-engineer in the work place.

**Contents:**
Training in the research laboratories, development laboratories and process laboratories, among others, of the industry and institutions in the field of their study is recommended to the students. The basic requirement is that the practice must be performed in a job supervised by a person who has taken an engineering degree.

The technical goal of practical training is to give a general insight of the field in which the trainee will work after having taken the degree and to support and to promote theoretical studying. Likewise, the training has to acquaint the trainee with the social points of the industrial production and with industrial safety and has to give a sufficient picture of the technical details of the performing of different work. Furthermore, the training has to give a general idea of the technical and economic organizing, administration and management of a company and its production.

**Mode of delivery:**
Independent work.

**Learning activities and teaching methods:**
The students acquire their training job themselves.

**Target group:**
MSc students.

**Prerequisites and co-requisites:**
-

**Recommended optional programme components:**
-

**Recommended or required reading:**
-

**Assessment methods and criteria:**
Students write a report on the compulsory MSc stage practical training lasting at least two months. This report is reviewed by degree program representatives. More detailed instructions for the report are available on the WWW pages of the degree program. Read more about assessment criteria at the University of Oulu webpage.

**Grading:**
Pass/Fail

**Person responsible:**
Hannu Sorvoja

**Working life cooperation:**
Yes.

**Other information:**
-

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**522991S: Master's Thesis in Radio Engineering, 30 cp**

**Form of study:** Advanced Studies

**Type:** Diploma thesis

**Unit:** Electrical Engineering DP

**Grading:** 1 - 5, pass, fail

**Opintokohteen kielet (E):** Finnish

No course descriptions.

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**521011S: Maturity Test for Master's Degree, Electronics and Communications Engineering, 0 cp**

**Form of study:** Advanced Studies

**Type:** Course
**Unit:** Electrical Engineering DP

**Grading:** 1 - 5, pass, fail

**Opintokohteen kielet (E):** Finnish

**Voidaan suorittaa useasti (E):** Yes

**ECTS Credits:**
0; The maturity test is integrated in the MSc Thesis credits (30 ECTS).

**Language of instruction:**
Finnish/Swedish/other

**Timing:**
1-4

**Learning outcomes:**
After the maturity test, the student has demonstrated that his/her language skills meet the requirements of the work life.

**Contents:**
The aim of the maturity test is to confirm the student's familiarity of the thesis area as well as his/her command of the domestic language of his/her school education.

**Mode of delivery:**
The maturity test is written in a controlled event, on a topic provided by the thesis supervisor.

**Learning activities and teaching methods:**
Written essay, approximately 3 pages.

**Target group:**
-

**Prerequisites and co-requisites:**
The maturity test can be written when the thesis is complete or being finished.

**Recommended optional programme components:**
-

**Recommended or required reading:**
MSc thesis

**Assessment methods and criteria:**
The maturity test is evaluated and approved by the thesis supervisor

Read more about assessment criteria at the University of Oulu webpage.

**Grading:**
Pass/fail.

**Person responsible:**
Thesis supervisor.

**Working life cooperation:**
-

**Other information:**
-

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**521998S: Master's Thesis in Telecommunication Engineering, 30 cp**

**Form of study:** Advanced Studies

**Type:** Diploma thesis

**Unit:** Electrical Engineering DP

**Grading:** 1 - 5, pass, fail

**Opintokohteen kielet (E):** Finnish

No course descriptions.

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**521011S: Maturity Test for Master's Degree, Electronics and Communications Engineering, 0 cp**

**Form of study:** Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Opintokohteen kielet (E): Finnish
Voidaan suorittaa useasti (E): Yes

ECTS Credits:
0; The maturity test is integrated in the MSc Thesis credits (30 ECTS).

Language of instruction:
Finnish/Swedish/other

Timing:
1-4

Learning outcomes:
After the maturity test, the student has demonstrated that his/her language skills meet the requirements of the work life.

Contents:
The aim of the maturity test is to confirm the student's familiarity of the thesis area as well as his/her command of the domestic language of his/her school education.

Mode of delivery:
The maturity test is written in a controlled event, on a topic provided by the thesis supervisor.

Learning activities and teaching methods:
Written essay, approximately 3 pages.

Target group:
-

Prerequisites and co-requisites:
The maturity test can be written when the thesis is complete or being finished.

Recommended optional programme components:
-

Recommended or required reading:
MSc thesis

Assessment methods and criteria:
The maturity test is evaluated and approved by the thesis supervisor
Read more about assessment criteria at the University of Oulu webpage.

Grading:
Pass/fail.

Person responsible:
Thesis supervisor.

Working life cooperation:
-

Other information:
-

Descriptions of courses and study modules not included in the degree structures

521026S: Advanced practical training, 5 cp

Validity: 01.01.2017 -
Form of study: Advanced Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Teachers: Hannu Sorvoja
Opintokohteen kielet (E): Finnish
Leikkaavuudet (E): 521016A Advanced Practical Training 3.0 cp

ECTS Credits:
5 ECTS credits

Language of instruction:
Finnish or English

Timing:
This course can be taken in periods I-IV. The recommended time to take this course is during summer of the fourth year.

Learning outcomes:
Student can apply knowledge and skills learned during university studies to complete work assignments in his/her own field.
Student can evaluate and develop himself/herself as a learner and worker.
Student can plan and evaluate his/her time management and working methods.
Student is capable of working in systematic and goal-oriented manner in group as well as independently.
Student can name important factors that direct the actions of work community and the employer.
Student can name duties where he/she can work after graduating from university.

Contents:
Planning and preparation, carrying out work assignments in the students field of studies, documentation of own accomplishments, writing report and reflection.

Mode of delivery:
Independent work.

Learning activities and teaching methods:
Student independently finds a place to work to complete the course. To pass the course minimum of two months of full time work is required. Work can also be carried out in multiple periods. The course works includes a) Making a practice plan for the working period 4 h, b) Documentation of progress during working 20 h, c) Learning while working 108 h, d) Final report and reflection 8 h.

Target group:
Master level students.

Prerequisites and co-requisites:
Recommended optional programme components:
The course does not require additional studies carried out at the same time. While carrying out the course working assignments are compared to already completed studies.

Recommended or required reading:
No required material.

Assessment methods and criteria:
Course is carried out by working minimum of two months in a work accepted by study program responsible person. Before starting the actual work the student needs to make a plan for the working period and return it to the responsible person. A weekly report is required from every working week. These reports have to turned in before the working period ends. After the working period is over the student writes a final report and returns it to the responsible person. Signed testimonial from the employer is also required with the final report.

Grading:
The course is graded as "pass/fail"

Person responsible:
Jukka Kontinen
Hannu Rautio

Working life cooperation:
The course is carried out as practical training.

Other information:
This course is alternative to 521016A Advanced Practical Training, 3 ECTS.

521907S: Fab Lab Digital Fabrication, 5 cp
Validity: 01.01.2019 -
Form of study: Advanced Studies
Type: Course
Unit: Faculty of Information Technology and Electrical Engineering
Grading: 1 - 5, pass, fail
Teachers: Jani Ylioja
Opintokohteen kielet (E): English

**ECTS Credits:**
5 ECTS

**Language of instruction:**
English

**Timing:**
Spring, periods 3-4.

**Learning outcomes:**
The student can:
1. demonstrate 2D design development for CNC production
2. describe workflows for CNC production
3. design appropriate objects within the limitations of 3 axis machining
4. demonstrate workflows used in mould design, construction and casting
5. identify the advantages and limitations of 3D printing and scanning technology
6. apply design methods and production processes to show one's understanding of 3D techniques
7. demonstrate workflows used in the chosen, changing process
8. select and apply suitable materials and processes to create one's project with selected process

**Contents:**
The student learns, theory and hands-on, small-scale digital fabrication techniques and prototyping for 2D, 2.5D and 3D: 3D-scanning and printing, CNC-machining, casting and moulds and one elective digital technique (embroidery, composites, etc.).

**Mode of delivery:**
Distributed and local lectures and exercises in four of one week long workshops.

**Learning activities and teaching methods:**
Lectures 24 h / excercises 64 h, self study the rest.

**Target group:**
M.Sc. students and other students.

**Prerequisites and co-requisites:**
Fab Lab Project Management.

**Recommended optional programme components:**
-

**Recommended or required reading:**

**Assessment methods and criteria:**
The course is passed with approved exercise reports.

**Grading:**
Pass / fail

**Person responsible:**
Jani Ylioja

**Working life cooperation:**
-

**Other information:**
-

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521905A: Fab Lab Electronics, 5 cp

Validity: 01.01.2019 -
Form of study: Intermediate Studies
**ECTS Credits:**
5 ECTS

**Language of instruction:**
English

**Timing:**
Spring, periods 3-4.

**Learning outcomes:**
The student can
1. describe the process of milling, stuffing, de-bugging and programming of self made printed circuit board with microcontroller
2. demonstrate correct workflows and identify areas for improvement if required
3. select and use software for circuit board design
4. demonstrate workflows used in circuit board design and fabrication
5. implement and interpret programming protocols

**Contents:**
The course gives basic knowledge of small scale digital fabrication and prototyping of printed circuit boards including design, fabrication and testing and gives examples of fabricating and using sensors and signaling devices or actuators with an embedded device.

**Mode of delivery:**
Distributed and local lectures and exercises in four of one week long workshops.

**Learning activities and teaching methods:**
Lectures 24 h / exercises 64 h, self study the rest.

**Target group:**
M.Sc. students and other students.

**Prerequisites and co-requisites:**
Fab Lab Project Management, Johdatus elektroniikkaan, Elektroniikkasuunnittelun perusteet.

**Recommended optional programme components:**
-

**Recommended or required reading:**
http://fabacademy.org/

**Assessment methods and criteria:**
The course is passed with approved exercise reports.

**Grading:**
Pass / fail

**Person responsible:**
Jani Ylioja

**Working life cooperation:**
-

**Other information:**
-

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**521906A: Fab Lab Programming, 5 cp**

**Validity:** 01.01.2019 -
ECTS Credits:
5 ECTS
Language of instruction:
English
Timing:
Spring, periods 3-4.
Learning outcomes:
The student can:
1. identify relevant information in a microcontroller data sheet
2. implement programming protocols
3. define the scope of a project and develop a project plan
4. demonstrate workflows used in network design
5. implement and interpret networking protocols
6. interpret and implement design and programming protocols to create a Graphic User Interface (GUI)
Contents:
Student learns to build machine-to-machine networks using self fabricated embedded devices. Student also learns networking between embedded and commercial devices such as personal computers or mobile phones. Student learns to program graphical interfaces for such systems.
Mode of delivery:
Distributed and local lectures and exercises in four of one week long workshops.
Learning activities and teaching methods:
Lectures 24 h / exercises 64 h, self study the rest.
Target group:
M.Sc. students and other students.
Prerequisites and co-requisites:
Fab Lab Project Management, Fab Lab Electronics, Ohjelmoinnin perusteet, Johdatus tietokonejärjestelmiin.
Recommended optional programme components:
-
Recommended or required reading:
http://fabacademy.org/
Assessment methods and criteria:
The course is passed with approved exercise reports.
Grading:
Pass / fail
Person responsible:
Jani Ylioja
Working life cooperation:
-
Other information:
-

521904A: Fab Lab Project Management, 5 cp

Validity: 01.01.2019 -
Form of study: Intermediate Studies
Type: Course
Unit: Faculty of Information Technology and Electrical Engineering
Grading: 1 - 5, pass, fail
Teachers: Jani Ylioja
Opintokohteen kielet (E): English

ECTS Credits:
5 ECTS
Language of instruction:
English

**Timing:**
Spring, periods 3-4.

**Learning outcomes:**
The student can:
1. communicate an initial project proposal
2. Explore and use website development tools
3. identify and utilise version control protocols
4. evaluate and select 2D and 3D software
5. demonstrate and describe processes used in modelling with 2D and 3D software
6. demonstrate and describe parametric 2D modelling processes
7. identify and explain processes involved in using the laser cutter
8. develop, evaluate and construct the final prototype of parametric design
9. identify and explain processes involved in using vinyl cutter
10. design and create the final object using vinyl cutter

**Contents:**
The course gives basic knowledge of managing digital fabrication processes. Subjects, from point of view of digital fabrication include version control, project management, computer aided design, computer controlled cutting using parametric design methods, intellectual property, inventions and income.

**Mode of delivery:**
Distributed and local lectures and exercises in five of one week long workshops.

**Learning activities and teaching methods:**
Lectures 30 h / exercises 80 h, self study the rest.

**Target group:**
M.Sc. students and other students.

**Prerequisites and co-requisites:**
Principles of Digital Fabrication.

**Recommended optional programme components:**
-

**Recommended or required reading:**
http://fabacademy.org/

**Assessment methods and criteria:**
The course is passed with approved exercise reports.

**Grading:**
Pass / fail

**Person responsible:**
Jani Ylioja

**Working life cooperation:**
-

**Other information:**
-

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**521908S: Fab Lab Project Work, 5 cp**

**Validity:** 01.01.2019 -

**Form of study:** Advanced Studies

**Type:** Course

**Unit:** Faculty of Information Technology and Electrical Engineering

**Grading:** 1 - 5, pass, fail

**Teachers:** Jani Ylioja

**Opintokohteen kielet (E):** English

**ECTS Credits:**
5 ECTS

**Language of instruction:**
English
Timing:
Spring, periods 3-4.

Learning outcomes:
The student can:
1. work and communicate effectively in a team and independently
2. design, plan and build a system
3. analyse and solve technical problems
4. recognise opportunities for improvements in the design
5. implement project plan
6. apply time management techniques
7. summarise and communicate the essence of one's project development
8. create one's own integrated design
9. demonstrate 2D & 3D modelling capabilities applied to one's own designs
10. select and apply appropriate additive and subtractive techniques
11. demonstrate competence in design, fabrication and programming of your own fabbed microcontroller PCB, including an input & output device

Contents:
The student learns to work in a team to digital fabrication. The group learns to make moc-up of a robot or a machine. The student also learns to apply suitable time management techniques for one's project and to integrate different skills to one functional product.

Mode of delivery:
Distributed and local lectures and exercises in three of one week long workshops and final project to integrate digital fabrication skills.

Learning activities and teaching methods:
Lectures 21 h / excercises 64 h, self study the rest.

Target group:
M.Sc. students and other students.

Prerequisites and co-requisites:
Fab Lab Project Management, Fab Lab Electronics, Fab Lab Programming, Fab Lab Digital Fabrication.

Recommended optional programme components:
-

Recommended or required reading:
http://fabacademy.org/

Assessment methods and criteria:
The course is passed with approved exercise reports.

Grading:
Pass / fail

Person responsible:
Jani Ylioja

Working life cooperation:
-

Other information:
-

521006P: Glimpse into ICT, 2 cp

Validity: 01.01.2020 -
Form of study: Basic Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Opintokohteen kielet (E): Finnish
Leikkaavuudet (E):
ay521006P Glimpse into ICT (OPEN UNIV) 2.0 cp
521015A: Practical Training, 3 cp

Validity: 01.08.2005 -  
Form of study: Intermediate Studies  
Type: Practical training  
Unit: Electrical Engineering DP  
Grading: 1 - 5, pass, fail  
Opintokohteen kielet (E): Finnish

ECTS Credits:  
3  
Language of instruction:  
Finnish/English  
Timing:  
1-4  
Learning outcomes:  
After the practical training the student can describe one possible future job and its working environment from the point of view of his or her studies. The student can identify problems in the work and suggest improvements. The student can find connections between work and studies. The technical goal of the training is to give a student a general insight into the field on which he or she will work after graduation, as well as support and promote theoretical studying. Likewise the training has to acquaint the trainee with the social aspects of industrial production and with industrial safety.

Contents:  
Learning about the requirements of working life, responsible contribution to the chosen work community, reporting.

Mode of delivery:  
The students find their training jobs themselves. It is recommended to participate University tuition sessions on training, career planning and employment issues, when available.

Learning activities and teaching methods:  
Independent work.

Target group:  
BSc students

Prerequisites and co-requisites:  
-

Recommended optional programme components:  
-

Recommended or required reading:  
-

Assessment methods and criteria:  
Students submit a training report of the min. 2 month training to the person responsible. More detailed instructions for the training report are available on the WWW pages of the degree program. Read more about assessment criteria at the University of Oulu webpage.

Grading:  
Pass/fail.

Person responsible:  
Hannu Sorvoja

Working life cooperation:  
Yes

Other information:  
Practical training is compulsory in the BSc. Tech (Electrical Engineering) degree for students who started in 2010 or earlier. For students starting 2011 or later, Practical Training is optional.

521018A: Practical training, 5 cp

Validity: 01.01.2017 -
Form of study: Intermediate Studies
Type: Course
Unit: Electrical Engineering DP
Grading: 1 - 5, pass, fail
Opintokohteen kielet (E): Finnish

ECTS Credits:
5 ECTS credits

Language of instruction:
Finnish or English

Timing:
This course can be taken in periods I-IV. The recommended time to take this course is during summer of the second year.

Learning outcomes:
Student can apply knowledge and skills learned during university studies to complete work assignments in his/her own field.
Student can evaluate and develop himself/herself as a learner and worker.
Student can plan and evaluate his/her time management and working methods.
Student is capable of working in systematic and goal-oriented manner in group as well as independently.
Student can name important factors that direct the actions of work community and the employer.
Student can name duties where he/she can work after graduating from university.

Contents:
Planning and preparation, introduction to work assignments related to students field of study, carrying out work assignments, documentation of own accomplishments, writing report and reflection.

Mode of delivery:
Independent work.

Learning activities and teaching methods:
Student independently finds a place to work to complete the course. To pass the course, minimum of two months of full time work is required. Work can also be carried out in multiple periods. The required elements are a) Making a practice plan for the working period 4 h, b) Documentation of progress during working 20 h, c) Learning while working 108 h, d) Final report and reflection 8 h

Target group:
Bachelor level students in electrical engineering

Prerequisites and co-requisites:

Recommended optional programme components:
The course does not require additional studies carried out at the same time. While carrying out the course working assignments are compared to already completed studies.

Recommended or required reading:
No required material.

Assessment methods and criteria:
Course is carried out by working minimum of two months in a work accepted by study program responsible person. Before starting the actual work the student needs to make a plan for the working period and return it to the responsible person. A weekly report is required from every working week. These reports have to be turned in before the working period ends. After the working period is over the student writes a final report and returns it to the responsible person. Signed testimonial from the employer is also required with the final report.

Grading:
The course is graded as "pass/fail".
Read more about assessment criteria at the University of Oulu webpage.

Person responsible:
Hannu Sorvoja

Working life cooperation:
The course is carried out in cooperation with companies.

Other information:
The BSc in electrical engineering degree can include optional practical training. This course is alternative to 521012A Practical Training, 3 ECTS.