Opasraportti

ITEE - Courses in English for exchange students (2020 - 2021)

University's new study guide for academic year 2020-2021 is published at https://opas.peppi.oulu.fi

The study guide includes information on degrees, curriculums, courses and course timetables. Course registrations are still done in Oodi.

If you have questions on information in the study guide, please contact the study field's Academic Affairs Service Team https://www.oulu.fi/forstudents/faculty-study-affairs

Courses in English for exchange students at the Faculty of Information Technology and Electrical Engineering

This Course Catalogue lists courses taught in English that are available for exchange students at the Faculty of Information Technology and Electrical Engineering (ITEE) during academic year 2020-21.

When preparing your study plan please use the information provided under the **Courses** tab in this catalogue. Read carefully the information of each course you wish to take (language of instruction, target group, course content, timing, preceding studies, additional information etc.).

For information on the exchange application process please see www.oulu.fi/university/studentexchange. All exchange applicants must submit their exchange application through SoleMOVE by the deadline given, proposed study plan is attached to the on-line application.

Accepted exchange students are required to register to all courses. Course registration takes place once you have received your University of Oulu login information, this takes place close to the start of your exchange period. When registering you will be able to find detailed information on teaching and schedule under the **Instruction** tab.

Teaching periods for 2020-21
Autumn term 2020
Period 1: Sept 1 - Oct 25, 2020
Period 2: Oct 26 – Dec 18, 2020

Spring term 2021
Period 3: Jan 5 – March 14, 2021
Period 4: March 15 – May 9, 2021

For arrival and orientation dates see www.oulu.fi/university/studentexchange/academic-calender

Any questions on courses at the Faculty of Information Technology and Electrical Engineering should be addressed to:
Virpi Parkkila, Faculty International Coordinator
virpi.parkkila(at)oulu.fi or study.itee(at)oulu.fi

Further information on application process and services for incoming exchange students:
www.oulu.fi/university/studentexchange or international.office(at)oulu.fi

Tutkintorakenteisiin kuulumattomat opintokokonaisuudet ja -jaksot

521176A: Laboratory Works of Electronic Measurement Techniques, 5 op
521016A: Advanced Practical Training, 3 op
812649S: Advanced Research Methods, 5 op
811602S: Advanced Software Quality and Security, 5 op
812650S: Advanced Topics in Digital Cultures and Design, 5 op
521026S: Advanced practical training, 5 op
521285S: Affective Computing, 5 op
521388S: Antennas, 5 op
521281S: Application Specific Signal Processors, 5 op
521041A: Applied Computing Project I, 8 op
521152S: Applied Computing Project II, 10 op
521495A: Artificial Intelligence, 5 op
523990A: Bachelor's Thesis / Electronics and Communications Engineering, 8 op
521283S: Big Data Processing and Applications, 5 op
521284S: Biomedical Engineering Project, 5 op
521093S: Biomedical Instrumentation, 5 op
521240S: Biophotonics and Biomedical Optics, 5 op
521273S: Biosignal Processing I, 5 op
521282S: Biosignal Processing II, 5 op
813316A: Business Process Modeling, 5 op
521325S: Communication Signal Processing, 5 op
521340S: Communications Networks I, 5 op
521377S: Communications Networks II, 7 op
521140S: Computer Graphics, 5 op
521155S: Computer Security, 5 op
521286A: Computer Systems, 8 op
521392S: Convex Optimization, 7 op
521042S: Creative Design, 5 op
811312A: Data Structures and Algorithms, 5 op
521153S: Deep Learning, 5 op
521337A: Digital Filters, 5 op
521467A: Digital Image Processing, 5 op
812352A: Digitalisation and Innovation, 5 op
521290S: Distributed Systems, 5 op
521115S: EMC Design, 5 op
521038A: Electrical Engineering Project Studies, 1 - 5 op
521039A: Electrical Engineering Project Studies 2, 1 - 5 op
521109A: Electrical Measurement Principles, 5 op
521092A: Electronic Measurement Techniques, 5 op
521124S: Electronic Sensors, 5 op
521405A: Electronic System Design, 5 op
521401S: Electronics Design II, 6 op
521435S: Electronics Design III, 6 op
521300S: Electronics Design and Construction Exercise, 6 op
521275A: Embedded Software Project, 8 op
521423S: Embedded System Project, 5 op
812351A: Enterprise Systems, 5 op
521292S: Fundamentals of Sensing, Tracking and Autonomy, 5 op
521145A: Human-Computer Interaction, 5 op
812651S: ICT and Behaviour Change, 5 op
817604S: ICT and Organizational Change, 5 op
813623S: Information Security Policy and Management in Organisations, 5 op

521390S: Information Theory, 5 op
521043S: Internet of Things, 5 op
521242A: Introduction to Biomedical Engineering, 5 op
521079S: Introduction to Nanotechnology, 5 op
031025A: Introduction to Optimization, 5 op
521157A: Introduction to Social Network Analysis, 5 op
521293A: Introduction to XR Systems, 5 op
521289S: Machine Learning, 5 op
521466S: Machine Vision, 5 op
521096S: Measurement Systems, 5 op
521075S: Microelectronics Packaging Technologies, 5 op
521074S: Microelectronics and Micromechanics, 5 op
521215S: Microelectronics project, 5 op
521072S: Microsensors, 5 op
521046A: Mobile Computing, 5 op
521318S: Modern Topics in Telecommunications and Radio Engineering, 3 - 7 op
521161S: Multi-Modal Data Fusion, 5 op
521288S: Multiprocessor Programming, 5 op
521158S: Natural Language Processing and Text Mining, 5 op
811606S: Next Generation Software Engineering, 5 op
031051S: Numerical Matrix Analysis, 5 op
521108S: Optical Measurement Technology Exercise, 5 - 10 op
521241A: Optical systems, 5 op
811607S: Persuasive Systems Design, 5 op
521448S: Physical Design of Digital Integrated Circuits, 5 op
521015A: Practical Training, 3 op
521018A: Practical training, 5 op
521159P: Principles of Digital Fabrication, 5 op
521229A: Principles of repurposing of electronics, 5 op
521089S: Printed Electronics, 5 op
521175S: Printed electronics design and construction exercise, 5 op
811373A: Professional Software Engineering Processes and Human Factors, 5 op
521260S: Programmable Web Project, 5 op
811330A: Project management, 5 op
521225S: RF Components and Measurements, 5 op
521386S: Radio Channels, 5 op
521326S: Radio Engineering 1, 5 op
521327S: Radio Engineering II, 6 op
813621S: Research Methods, 5 op
812354A: Servitisation, Co-Creation and Business Development, 5 op
521279S: Signal Processing Systems, 5 op
521328A: Simulations and Tools for Telecommunications, 5 op
521044A: Social Computing, 5 op
811372A: Software Development, Maintenance and Operations, 5 op
815663S: Software Engineering Research, 5 op
811603S: Software Platforms and Ecosystems, 5 op
521479S: Software Project, 7 op
811604S: Software for Intelligent Systems and Artificial Intelligence (AI), 5 op
811605S: Software-Defined Products, Systems and Services, 5 op
521149S: Special Course in Information Technology, 5 - 8 op
521393S: Statistical Communication Theory, 7 op
521348S: Statistical Signal Processing 1, 5 op
521324S: Statistical Signal Processing II, 5 op
521322S: Telecommunication Engineering Project, 5 op
521402S: Telecommunications Circuit Design, 6 op
521098S: Testing Techniques of Electronics and Printed Electronics, 5 op
521156S: Towards Data Mining, 5 op
521154S: UBISS - International UBI Summer School, 5 op
812355A: User Experience (UX) Design and Management, 5 op
812671S: User Experience (UX) and Usability Evaluation, 5 op
521291S: VR Systems and Humans, 5 op
521395S: Wireless Communications I, 5 op
521349S: Wireless Communications II, 5 op
521097S: Wireless Measurements, 5 op

Opintojaksojen kuvaukset

Tutkintorakenteisiin kuulumattomien opintokokonaisuuksien ja -jaksojen kuvaukset

521176A: Laboratory Works of Electronic Measurement Techniques, 5 op

Voimassaolo: 01.08.2020 -
Opiskelumuoto: Intermediate Studies
Laji: Course
Vastuuyksikkö: Electrical Engineering DP
Arvostelu: 1 - 5, pass, fail
Opettajat: Christian Schuss
Opintokohteen kielet: Finnish

ECTS Credits:
5 ECTS cr
Language of instruction:
English. Some of supervisors can Finnish or Russian
Timing:
Period 4.
Learning outcomes:
The student The student
1. can design and conduct measurements to define amplifier and filter properties,
2. can design and conduct measurements with spectrum analyser and FFT oscilloscope,
3. can design and conduct measurements to define light and photosensor properties.
4. can apply techniques to increase precision and can detect and reject interference,
5. can use a fiber lidar.
Contents:
An overview to electronic measurements by concentrating to few topics: temperature, light and moisture sensors, measurements of filter and amplifier properties, frequency domain measurements, lidar measurements, reject of interference and noise.
Mode of delivery:
Face-to-face teaching
Learning activities and teaching methods:
Lecture hall teaching (Start and end lecture) 4h, laboratory work 30 h and independent work 100 h.
Target group:
Course is recommended as a voluntary course to all engineering students. All students of the University of Oulu can attend the course.
Recommended optional programme components:
This course can replace Electronic measurement techniques.
Recommended or required reading:
Course material is in Moodle.
Assessment methods and criteria:
The course is passed when all laboratory works are passed.
Grading:
Pass or fail
Person responsible:
Christian Schuss
Working life cooperation:
No.

521016A: Advanced Practical Training, 3 op

Voimassaolo: 01.08.2005 -
Opiskelumuoto: Intermediate Studies
Laji: Practical training
Vastuuyksikkö: Electrical Engineering DP
Arvostelu: 1 - 5, pass, fail
Opintokohteen kielet: Finnish
Leikkaavuudet:

521026S Advanced practical training 5.0 op

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:
Jari Hannu
Working life cooperation:
Yes.
Other information:
-

812649S: Advanced Research Methods, 5 op

Voimassaolo: 01.08.2016 -
Opiskelumuoto: Advanced Studies
Laji: Course
Vastuuyksikkö: Faculty of Information Technology and Electrical Engineering
Arvostelu: 1 - 5, pass, fail
Opettajat: Netta Iivari
Opintokohteen kielet: English

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 at the 2nd spring semester of the Master's studies.
Learning outcomes:
After completing the course, the student will be able to:
* describe the background, philosophical assumptions and guiding principles of quantitative, qualitative and design science research, their role in information systems and software engineering research and the variety involved in them;
* evaluate the strengths and weaknesses of the research approaches and methods in relation to her or his research topic as well as select the suitable approach and methods;
* use more advanced data analysis methods;
* prepare a research plan for a research project, including formulating research problems, specifying research designs and choosing appropriate data collection and analysis methods for solving the problems;
* describe state-of-the-art ways of reporting the results;
* evaluate the methodological quality of her or his research and research publications more generally; as well as
* search more information on research methods from scientific literature as well as to adapt and refine methods for her or his research problems and interests.
Contents:
Introduction to qualitative, quantitative and design science research in information systems and software engineering, their scientific background,
philosophical assumptions and guiding principles, variety involved in them, relationships between the research approaches and associated frameworks, methods, processes and practices, advanced data analysis methods, reporting and evaluating research within the approaches.
Mode of delivery:
Face-to-face teaching
Learning activities and teaching methods:
Lectures 16 h, exercises 12 h, seminar 18 h, individual and group assignments 100 h
Target group:
MSc students, PhD students
Prerequisites and co-requisites:
The required prerequisite is that the learning outcomes of the following courses are accomplished: Research Methods. In addition, the student must have a preliminary thesis topic.
Recommended optional programme components:
Recommended to take before Master's thesis.
Recommended or required reading:
Selected scientific articles or research method books.
Assessment methods and criteria:
Assignments
Grading:
Pass or fail
Person responsible:
Netta Iivari

811602S: Advanced Software Quality and Security, 5 op

Voimassaolo: 01.08.2019 -
Opiskelumuoto: Advanced Studies
Laji: Course

Vastuuyksikkö: Information Processing Science DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Mika Mäntylä, Alireza Haghighatkhah

Opintokohteen kielet: English

ECTS Credits:
5 ECTS credits / 133 hours of work
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 2nd autumn semester of the Master's studies.
Learning outcomes:
After completing the course, the student will be able to:
* understand and utilize software quality models,
* understand and utilize some software testing and security techniques, and understand their benefits and limitations, as well as
* apply software testing and security techniques in small scale projects.
Contents:
* Testing and quality techniques: Model-based testing, search-based testing, defect prediction, exploratory testing, combinatorial testing, static testing, static analyzers, virtualization, test automation,
* Security Attacks buffer overflows, command injection; Security testing: vulnerability scanning, intrusion detection.
Mode of delivery:
Face-to-face teaching
Learning activities and teaching methods:
Lecture 16 h, Exercises 24 h
Target group:
MSc students
Prerequisites and co-requisites:
The required prerequisite is that the learning outcomes of the following courses and their predecessors are accomplished: Professional Software Engineering Processes and Human Factors.
Recommended or required reading:
Lectures, Slides, Articles
Assessment methods and criteria:
Assignments, Exercises, Essays
Grading:
Numerical scale 1-5 or fail
Person responsible:
Alireza Haghighatkhah

812650S: Advanced Topics in Digital Cultures and Design, 5 op

Voimassaolo: 01.08.2011 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Information Processing Science DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Dorina Rajanen

Opintokohteen kielet: English

ECTS Credits:
5 ECTS credits / 133 hours of work
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's studies.
Learning outcomes:

After completing the course, the student will be able to:
* describe state-of-the-art research results related to digital cultures and design;
* understand the strengths and limitations of various methods and frameworks used;
* show competence in critiquing research articles published in some of the leading academic journals and conference proceedings;
* show competence in critical thinking, and analysis and synthesis of academic sources;
* show competence in verbally presenting arguments in an academic fashion;
* write a literature review on a relevant research topic;
* acquire knowledge and critically read relevant research articles on digital culture and design related research topics; as well as
* describe ethical aspects involved with work related to digital cultures and design.

Contents:
The content of the course will change with time. The initial set of current themes include: User experience as an object of analysis and design, Participatory design, end-user-design and living labs, Information ecologies and infrastructures, Design for all, Iterative and incremental design and development, The impact of human-centred design, Current development contexts such as: Open source software development, Game development, Development of ICT for children, Ubiquitous computing

Mode of delivery:
Face-to-face teaching.

Learning activities and teaching methods:
Lectures 20 h, assignments 107 h, seminars 6 h.

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 optional programme components:

Recommended or required reading:
Selected scientific articles.

Assessment methods and criteria:
Assignments

Grading:
Numerical scale 1-5 or fail

Person responsible:
Mikko Rajanen

521026S: Advanced practical training, 5 op

Voimassaolo: 01.01.2017 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Electrical Engineering DP

Arvostelu: 1 - 5, pass, fail

Opintokohteen kielet: Finnish

Leikkaavuudet:

521016A Advanced Practical Training 3.0 op

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 raport 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 assigments 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.

521285S: Affective Computing, 5 op

Voimassaolo: 01.08.2015 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Computer Science and Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Guoying Zhao

Opintokohteen kielet: 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:
Online teaching in Moodle/Zoom.
Moodle: https://moodle.oulu.fi/course/view.php?id=325&section=0
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
Other information:
Course work space can be found from University of Oulu Moodle platform moodle.oulu.fi.

521388S: Antennas, 5 op

Voimassaolo: 01.08.2015 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Electrical Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Markus Berg

Opintokohteen kielet: English

Leikkaavuudet:

521380S	Antennas	4.0 op
521380S-01	Antennas, partial credit	0.0 op
521380S-02	Antennas, partial credit	0.0 op

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:
Introduction to different antenna types. Fundamental parameters of antennas. Antennas as a part of a radio system. Radiation of an antenna from the Maxwell's equations. Typical linear wire antennas. Loop antennas. Microstrip antennas. Antenna arrays. Antennas for wireless devices. Antenna - human body interaction. Base station antennas. 3D electromagnetic simulation.
Mode of delivery:
Online 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:
Recommended literature: C.A. Balanis: Antenna Theory, Analysis and Design (3rd or 4th Ed). John Wiley & Sons, 2005 or 2016. Chapters 1-6 and 14.
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:
-

521281S: Application Specific Signal Processors, 5 op

Voimassaolo: 01.08.2012 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Computer Science and Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Mehdi Safarpour

Opintokohteen kielet: 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.

521041A: Applied Computing Project I, 8 op

Voimassaolo: 01.08.2018 -

Opiskelumuoto: Intermediate Studies

Laji: Course

Vastuuyksikkö: Computer Science and Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Ojala, Timo Kullervo

Opintokohteen kielet: Finnish, English

Leikkaavuudet:

521151A	Applied Computing Project I	10.0 op

ECTS Credits:
8 ECTS credits / 216 hours of work
Language of instruction:
Finnish and English
Timing:
The course is held in the spring semester, during periods III and IV. It is recommended to complete the course during the 3rd year.
Learning outcomes:
Upon completion of the course, the student will be able to:
1. has basic understanding on how to collaboratively design a small-scale software project,
2. has basic understanding on how to implement and evaluate a small-scale software project,
3. is able to extensively document a small-scale software project,
4. is able to present and "pitch" a project work, i.e. give a good, concise presentation of the work
Contents:
The basics concepts and practices of implementing a software project in the domain of applied computing
Mode of delivery:
Online teaching, project work in groups
Learning activities and teaching methods:
8 hours of introductory lectures. Majority of the course is guided project work

Target group:
3rd year Computer Science and Engineering B.Sc. students and other Students of the University of Oulu.
Prerequisites and co-requisites:
Elementary Programing (521141P), Human-Computer Interaction (521145A) or corresponding 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:
Dix, Finlay, Abowd & Beale: Human-Computer Interaction (http://www.hcibook.com); Rogers, Sharp & Preece: Interaction Design: Beyond Human-Computer Interaction (http://www.id-book.com).
Assessment methods and criteria:
The course uses continuous assessment so that the project work is assessed in stages: design (20% of total grade), implementation (40%), evaluation (20%), and final report (20%). Passing criteria: all stages (design, implementation, evaluation, report) must be completed with an approved grade. Read more about assessment criteria at the University of Oulu webpage.
Grading:
Numerical grading scale 1-5; zero stands for a fail.
Person responsible:
Timo Ojala
Working life cooperation:
The projects that the students will undertake are defined either by the research group or industry partners. In the projects defined by the industry, the students will carry out a development project to create a solution for the company's genuine and existing challenges. The project reports regularly to the project steering group consisting of a supervising teaching assistant as well as the company representative. In addition, the course canl have guest lectures from industry regarding collaborative software development and evaluation practices.
Other information:
The 521275A course offers the possibility to complete your Bachelor thesis in a structured course environment. The course is suitable also for students who do not use the course for their Bachelor Thesis.
Using Google Glassroom.

The course is in Moodle: https://moodle.oulu.fi/course/view.php?id=5086

521152S: Applied Computing Project II, 10 op

Voimassaolo: 01.08.2013 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Computer Science and Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Ojala, Timo Kullervo

Opintokohteen kielet: English

ECTS Credits:
10 ECTS cr
Language of instruction:
English.
Timing:
Autumn and Spring, periods 1-4.
Learning outcomes:
1. has advanced understanding on how to collaboratively design a medium-scale software project,

2. has advanced understanding on how to implement and evaluate a medium-scale software project,

3. is able to extensively document a medium-scale software project,

4. has advanced skills in presenting and pitching a project work, i.e. give a good, concise presentation of the work,
Contents:
Project work that is typically executed in groups of 3-5 students. Note: the project work cannot be done alone.
Mode of delivery:
3-4 lectures to introduce and conclude the course and project works, collaborative project work for a "client" (teaching assistants and/or industry representatives).
Learning activities and teaching methods:

Practical work in project teams. The course is passed with an approved project work. The implementation is fully in English.
Target group:
Computer Science and Engineering MSc students and other Students of the University of Oulu.
Prerequisites and co-requisites:
While no specific courses are not required, 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.
Recommended or required reading:
For additional reading (not mandatory): Dix, Finlay, Abowd & Beale: Human-Computer Interaction (http://www.hcibook.com); Rogers, Sharp & Preece: Interaction Design: Beyond Human-Computer Interaction (http://www.id-book.com).
Assessment methods and criteria:
The course uses continuous assessment so that the project work is assessed in stages: design (20% of total grade), implementation (40%), evaluation (20%), and final report (20%). Passing criteria: all stages (design, implementation, evaluation, report) must be completed with an approved grade.
Read more about assessment criteria at the University of Oulu webpage.
Grading:
Numerical grading scale 1-5; zero stands for a fail.
Person responsible:
Timo Ojala
Working life cooperation:
No

521495A: Artificial Intelligence, 5 op

Voimassaolo: 01.08.2012 -

Opiskelumuoto: Intermediate Studies

Laji: Course

Vastuuyksikkö: Computer Science and Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Pekka Sangi, Jaakko Suutala

Opintokohteen kielet: English

Leikkaavuudet:

ay521495A	Artificial Intellig (OPEN UNI)	5.0 op

ECTS Credits:
5 ECTS credits / 135 hours of work
Language of instruction:
English
Timing:
The course in held in the spring semester, during period III. For bachelor students of Computer Science and Engineering specializing to artificial intelligence, it is recommended to complete the course at the 3rd spring semester.
Learning outcomes:
After completing the course, students

1. know the basic search strategies that can be applied in problem solving and optimization.
2. understand how search-based decisions are made in game-like competitive applications.
3. know the basic principles of probabilistic reasoning in artificial intelligence systems.
4. know how rational decision making under uncertainty can be formulated using utility theory.
5. understand the fundamentals of machine learning and how some of the established methods can be applied to problems in AI.
6. are familiar with advanced AI applications of perception and robotics and how probabilistic inference and machine learning can be used in these settings.

In the course projects, students get some experience in programming and using search methods.
Contents:
intelligent agent types, uninformed search methods, informed (heuristic) search, local search, constraint satisfaction problems, adversarial search, uncertainty handling, probabilistic reasoning, utility, machine learning, decision networks, Markov decision process, reinforcement learning, applications
Mode of delivery:

The tuition is implemented as web-based teaching. Moodle environment is used in the course.
Due to Covid-19 pandemic, teaching in Spring 2021 will be implemented remotely. Course work space can be found from University of Oulu Moodle platform.
Moodle page in Spring 2021 will be https://moodle.oulu.fi/course/view.php?id=3211, where details of implementation will be provided. The page will be available from December 21, 2020.
Online lectures will be given with Zoom and link for them will be provided in Moodle.

Learning activities and teaching methods:
Lectures 28 h / Group work (programming projects) 42 h / Self-study 65 h

Target group:
The primary target group is the students of the Computer Science and Engineering specializing in Artificial Intelligence.

Prerequisites and co-requisites:
Completion of the course "521160P Introduction to Artificial Intelligence" (lectured in Finnish) is recommended, but is not a prerequisite. It is also recommended that a student has completed studies related to probability and statistics (e.g. course "031021P Probability and Mathematical Statistics") and Python programming (e.g. course "521141P Elementary Programming").

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 the book Stuart Russell, Peter Norvig (2010, global edition 2016): Artificial Intelligence: A Modern Approach (3rd Edition), Chapters 1-6, 13-18, 20-21, partly 24-25.
The course utilizes materials of an introductory course on artificial intelligence taught at UC Berkeley (http://ai.berkeley.edu).

Assessment methods and criteria:
The assessment of the course is based on the final exam. Both the final exam and the course projects must be passed. Well-done course projects can increase the grade by one unit.

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

Person responsible:
Pekka Sangi, Jaakko Suutala

Working life cooperation:
The course does not contain working life cooperation.

Other information:
Course work space can be found from University of Oulu Moodle platform moodle.oulu.fi.
Moodle page in Spring 2021 will be https://moodle.oulu.fi/course/view.php?id=3211

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

Voimassaolo: 01.08.2007 -

Opiskelumuoto: Intermediate Studies

Laji: Course

Vastuuyksikkö: Electrical Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Jari Hannu

Opintokohteen kielet: 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 Electrocal Engineering and Communications Engineering.
Working life cooperation:
Yes.
Other information:
-

521283S: Big Data Processing and Applications, 5 op

Voimassaolo: 01.08.2015 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Computer Science and Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Lauri Lovén

Opintokohteen kielet: 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 fundatmenals, data storage, batch and stream data processing, data analysis, privacy and security, big data use cases.
Mode of delivery:
Online teaching, exercises and seminars. 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:
Finishing 521290S Distributed Systems, 521497S Pattern recognition and neural networks, and 521286A Computer Systems is beneficial.
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:
Lauri Lovén
Working life cooperation:
The course includes also invited lectures from industry.
Other information:
Course is in Moodle.

521284S: Biomedical Engineering Project, 5 op

Voimassaolo: 01.01.2015 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Computer Science and Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Tapio Seppänen

Opintokohteen kielet: Finnish

ECTS Credits:
5 ECTS credits
Language of instruction:
English.
Timing:
As part of the master level studies, in any period suitable to the student.
Learning outcomes:
1. has develop skills for being initiative, creativity, application of theoretical knowledge, programming and cooperation.
Contents:
A small-scale research work in an active research group. Topics will be selected from the needs of present research activities in the site of work and the interests of student. Main emphasis is on the development and application of methods and algorithms for biomedical data processing. Often the work includes programming with Matlab, C or Java languages.
Mode of delivery:
Self-study under supervision.
Learning activities and teaching methods:
First the research group is studied to get understanding of what are its goals. Detailed task description is written with the advisor. Typically, the work includes study of theoretical background information, programming, testing and simulations, and documentation. Task assignments can be applied at any time all year round.
Target group:
Master-level students that are interested in biomedical engineering. 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. Courses such as Biosignal processing I and II, Biomedical image processing and Machine learning are recommended. Programming skills, especially 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:
Literature and scientific articles depending on the task assignment.
Assessment methods and criteria:
Course assessment is based on the technical report.
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

521093S: Biomedical Instrumentation, 5 op

Voimassaolo: 01.08.2015 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Electrical Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Teemu Myllylä

Opintokohteen kielet: Finnish

Leikkaavuudet:

521107S Biomedical Instrumentation 6.0 op

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 signals commonly measured 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). Introduction to medical imaging and monitoring methods and instruments and physical therapy devices. Electrical safety aspects.
Mode of delivery:
Face-to-face teaching.
Learning activities and teaching methods:
Lectures/exercises 30 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:
R. S. Khandpur: Biomedical Instrumentation, Technology and Applications, McGraw-Hill, 2005 and J. G. Webster: Medical Instrumentation, Application and Design, 4th edition, John Wiley & Sons, 2010.
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.

521240S: Biophotonics and Biomedical Optics, 5 op

Voimassaolo: 01.08.2015 -
Opiskelumuoto: Advanced Studies
Laji: Course
Vastuuyksikkö: Electrical Engineering DP
Arvostelu: 1 - 5, pass, fail
Opettajat: Alexey Popov, Aliaksandr Bykau
Opintokohteen kielet: 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:
Online teaching.
The information about the remote teaching of the course: 521240S Biophotonics and Biomedical Optics has been added to the course workspace in moodle https://moodle.oulu.fi/course/view.php?id=2436&section=0
Shortly, the lectures and seminars will be organized remotely via the zoom environment.
The corresponding link will be published on the moodle page prior to the lecture.
The exam/test will performed online through the moodle or google forms at the estimated day.

Learning activities and teaching methods:
Lectures/exercises 38 h and self-study 100 h.
The information about the remote teaching of the course: 521240S Biophotonics and Biomedical Optics has been added to the course workspace in moodle https://moodle.oulu.fi/course/view.php?id=2436&section=0
Shortly, the lectures and seminars will be organized remotely via the zoom environment.
The corresponding link will be published on the moodle page prior to the lecture.
The exam/test will performed online through the moodle or google forms at the estimated day.
Target group:
Students interested in biomedical measurements.
Prerequisites and co-requisites:
None.
Recommended optional programme components:
A new course
Recommended or required reading:
V.V Tuchin: Handbook of Optical Biomedical Diagnostics, SPIE Press, 2002; V.V Tuchin: Handbook of Coherent Domain Optical Methods, Springer, 2nd edition, 2013. D.A Boas, C. Pitris, N. Ramanujam, Handbook of Biomedical Optics, CRC Press, 2011.
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.

521273S: Biosignal Processing I, 5 op

Voimassaolo: 01.08.2005 -
Opiskelumuoto: Advanced Studies
Laji: Course
Vastuuyksikkö: Computer Science and Engineering DP
Arvostelu: 1 - 5, pass, fail
Opettajat: Tapio Seppänen, Zalan Rajna
Opintokohteen kielet: Finnish

ECTS Credits:
5 ECTS credits.
Language of instruction:
English.
Timing:
The course unit is held in the autumn semester, during period 2. It is recommended to complete the course at the master's degree level.
Learning outcomes:
After completing the course, student:
1. knows about special characteristics of the biosignals and typical signal processing methods
2. can solve small-scale problems related to biosignal analysis
3. implement small-scale MATLAB software for signal processing algorithms.

Contents:
Biomedical signals. Digital filtering. Analysis in time-domain and frequency domain. Nonstationarity. Event detection. Signal characterization.
Mode of delivery:
Face-to-face teaching and guided laboratory work. The laboratory work can alternatively be performed on an online system (MathWorks Grader). Student can do the lab works remotely or in the lab using the same online system.
Learning activities and teaching methods:
Lectures 12h, Laboratory work 24h, Self-study for laboratory working and examination 99 h.
Target group:
Students interested in digital signal processing applications in biomedical engineering, at their master's level studies.
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:
Face-to-face lectures. Students solve the programming problems in the laboratory work independently, supervised by assistants. The MathWorks Grader online system is used for programming tasks and it also verifies the completed tasks. Written examination.
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 op

Voimassaolo: 01.08.2015 -
Opiskelumuoto: Advanced Studies
Laji: Course
Vastuuyksikkö: Computer Science and Engineering DP
Arvostelu: 1 - 5, pass, fail
Opettajat: Jukka Kortelainen
Opintokohteen kielet: Finnish
Voidaan suorittaa useasti: Kyllä

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:
Online teaching / Moodle
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:
-
Other information:
Course work space can be found from University of Oulu Moodle platform moodle.oulu.fi.

813316A: Business Process Modeling, 5 op

Voimassaolo: 01.08.2010 -
Opiskelumuoto: Intermediate Studies
Laji: Course
Vastuuyksikkö: Information Processing Science DP
Arvostelu: 1 - 5, pass, fail
Opettajat: Karin Väyrynen

Opintokohteen kielet: English

ECTS Credits:
5 ECTS credits / 133 hours of work.
Language of instruction:
English
Timing:
The course is held in the spring semester, during period 4. It is recommended to complete the course at the 3rd spring semester of the Bachelor's studies.
Learning outcomes:
After completing the course, the student will be able to:
* model and design business processes;
* use a computer-based process modeling tool;
* distinguish between business process change on the enterprise level, business process level and the implementation level; as well as
* design process architecture in teamwork with other students.
Contents:
Process architecture and how it can be fitted to the organisation, process modelling, process performance measurement, understanding process-related problems, process development, software tools for modelling and analysing processes, exercises.
Mode of delivery:
Face-to-face teaching.
Learning activities and teaching methods:
Lectures 26 h (or exam), exercises 13 h, individual assignments (lecture assignments, small process model, etc.) 34 h, large process model (group work) 60 h.
Target group:
BSc students.
Recommended or required reading:
Harmon, Paul (2007). Business Process Change. A Guide for Business Managers and BPM and Six Sigma Professionals. Morgan Kaufmann Publishers. Additional material to be announced during the course.
Assessment methods and criteria:
This course unit utilizes continuous assessment. Students can either participate in the lectures (min. 85 % attendance required) or take the exam. All students will write lecture assigments, and will create a process architecture / model with a software tool. The assessment of the course unit is based on the learning outcomes of the course unit.
Grading:
Numerical scale 1-5 or fail.
Person responsible:
Karin Väyrynen

521325S: Communication Signal Processing, 5 op

Voimassaolo: 01.08.2015 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Electrical Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Juntti, Markku Johannes

Opintokohteen kielet: English

Leikkaavuudet:

521360S	Synchronisation for Digital Receivers	4.0 op
521360S-01	Synchronization for Digital Receivers, exam	0.0 op
521360S-02	Exercise work, Communication Signal Processing II	0.0 op

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:

Remote teaching and e-learning tool usage.

Learning activities and teaching methods:

Remote 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:

1. P. P. Vaidyanathan, S.-M. Phoong & Y.-P. Lin, “Signal Processing and Optimization for Transceiver Systems”, Cambridge University Press, 2010.
2. P. Prandoni & M. Vetterli, “Signal Processing for Communications”, CRC Press 2008.
3. H. Meyr, M. Moeneclaey & S. A. Fechtel, “Digital Communication Receivers: Synchronization, Channel, Estimation and Signal Processing”. John Wiley, 1998.
4. F. Ling, “Synchronization in Digital Communication Systems”, Cambridge University Press, 2017.
5. Steven M. Kay, "Fundamentals of statistical signal processing: Detection theory,” vol. 2. Prentice Hall 1998.
6. 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.

521340S: Communications Networks I, 5 op

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Electrical Engineering DP

Arvostelu: 1 - 5, pass, fail
Opettajat: Mika Ylianttila
Opintokohteen kielet: 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:
Due to Covid-19 pandemic, teaching in Autumn 2020 will be implemented remotely. Details of arrangement can be found from the course web page, which will be available in Moodle.
https://moodle.oulu.fi/course/view.php?id=1454
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 (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:
-

521377S: Communications Networks II, 7 op

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Electrical Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Mika Ylianttila

Opintokohteen kielet: 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:
Due to Covid-19 pandemic, teaching in Autumn 2020 will be implemented remotely. Details of arrangement can be found from the course web page, which will be available in Moodle.
https://moodle.oulu.fi/course/view.php?id=1457
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 (Moodle).
Target group:
1 st 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:

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 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:
-

521140S: Computer Graphics, 5 op

Voimassaolo: 01.08.2018 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Computer Science and Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Guoying Zhao

Opintokohteen kielet: English

Leikkaavuudet:

521493S	Computer Graphics	7.0 op

ECTS Credits:
5 ECTS credits

Language of instruction:
In English

Timing:
Spring, period 4.

Learning outcomes:
Upon comletion of the course, the student

1. is able to specify and design 2D graphics algorithms including: line and circle drawing, polygon filling and clippin
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:
Remote teaching

Learning activities and teaching methods:
Lectures 22 h / Programming lessons 12 hours / Self-study and programming assignments 101 h.

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:
1) Textbook: Edward Angel, Dave Shreiner: Interactive Computer Graphics: A Top-Down Approach with WebGL, 7th Edition, Addison-Wesley 2015

2) Textbook: Edward Angel: Interactive Computer Graphics, 5th Edition, Addison-Wesley 2008
3) Reference: Peter Shirley, Michael Ashikhmin, Michael Gleicher, et al. : Fundamentals of Computer Graphics, second edition, AK Peters, Ltd. 2005
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 (70%) and programming assignments (30%).
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, Tuomas Varanka, Muzammil Behzad.
Working life cooperation:
No
Other information:
Course work space can be found from University of Oulu Moodle platform moodle.oulu.fi.

521155S: Computer Security, 5 op

Voimassaolo: 01.08.2017 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Computer Science and Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Teemu Tokola, Juha Röning

Opintokohteen kielet: 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:
-
Other information:
Course work space can be found from University of Oulu Moodle platform moodle.oulu.fi.

521286A: Computer Systems, 8 op

Voimassaolo: 01.08.2015 -

Opiskelumuoto: Intermediate Studies

Laji: Course

Vastuuyksikkö: Computer Science and Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Teemu Leppänen

Opintokohteen kielet: Finnish

Leikkaavuudet:

521142A	Embedded Systems Programming	5.0 op

ECTS Credits:
8 ECTS cr
Language of instruction:
Lecturing in Finnish, course and exercise material available in English.
Timing:
Autumn, periods 1-2.
Learning outcomes:
Upon completion of the course:
Student understands the basic computer architecture and organization.
Student understands CPU operation and basic datapath operation.
Student knows different number systems and data representations in computers.
Student is familiar of I/O operation with peripheral devices in general.
Student is able to implement small programs with the C programming language for general-purpose computers for embedded systems.
Student is able to implement small assembly language programs.
Student recognizes how embedded systems programming is different from programming general-purpose computers.
Contents:
Overview of computer architecture and organization, CPU and datapath, memory hierarchies, data types, interrupts, registers and I/O, basics of the C programming language and basics of assembly language. Embedded systems programming.
Mode of delivery:
Web-based teaching + face-to-face teaching.
Learning activities and teaching methods:
Lectures (32h), course exercises (10-30h), laboratory exercise (3h) and two course projects, one is completed in a group and the other alone.

Target group:
2nd year students of computer science and engineering and 3rd year students of Electronics and Communications Engineering.
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.
Literature:
Bryant & O'Hallaron, Computer Systems: A Programmer's Perspective, 3rd Edition, Chapters 1-9.
Patterson & Hennessy, Computer Organization and Design: The Hardware/Software Interface, 5th Edition, Chapters 1-2, 4-5.
Patterson & Hennessy, Computer Organization and Design, 5th Edition: The Hardware/Software Interface, 2014.
Bryant & O'Hallaron, Computer Systems: A Programmer's Perspective, 2016.

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 projects. Assessment is based on the exercises and the course projects. More detailed information on assessment is published in the lecture material.
Grading:
Numerical grading scale 1-5, zero stands for fail.
Person responsible:
Teemu Leppänen
Working life cooperation:
Visiting lectures with experts from local industry are possible.
Other information:
The course learning platform is Lovelace (lovelace.oulu.fi).

521392S: Convex Optimization, 7 op

Voimassaolo: 01.08.2019 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Electrical Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Antti-Heikki Tölli, Italo Atzeni

Opintokohteen kielet: Finnish

ECTS Credits:
7 ECTS cr (521392S Convex Optimization) or
10 ECTS cr (522010J Convex Optimization)
Language of instruction:
English
Timing:
Autumn 2020 (periods 1 and 2).
Learning outcomes:

- The students will be able to recognize, formulate, reformulate, and solve various engineering problems as convex optimization problems, both analytically and algorithmically.
- The students will be able to identify convex sets, convex functions, and different types of convex optimization problems.
- The students will learn the necessary and sufficient conditions for optimality, as well as the essential concepts of duality.
- The students will be able to write basic MATLAB solvers based on CVX and disciplined convex programming.
- The students will learn high-level algorithmic optimization aspects and will be able to write basic MATLAB solvers.

Contents:

- Convex sets
- Convex functions

- Convex optimization problems: linear problems, quadratic problems, second-order cone programming, geometric programming, semidefinite programming
- Duality
- CVX and disciplined convex programming
- Optimization algorithms: unconstrained minimization (Newton´s methods), equality-constrained minimization, inequality-constrained optimization (interior-point methods)
- Applications: regression and fitting, beamforming, primal and dual decomposition, linear programming /geometric programming applications, sparse and low-rank optimization

Mode of delivery:
Face-to-face teaching (F2F) teaching
Learning activities and teaching methods:
F2F lectures, self-lectures, homework, and final project.
Target group:
Primarily ITEE Master's and PhD students, but other students from the University of Oulu are also welcome. The course should benefit anyone who uses or will use scientific computing or optimization in engineering or related fields (e.g., communications, signal processing, machine learning and control).
Prerequisites and co-requisites:

- Required: solid knowledge of linear algebra (e.g., 031051S "Numerical matrix analysis") and random processes, good knowledge of MATLAB programming.
- Desirable: exposure to numerical computing/optimization (e.g., 031025A "Introduction to optimization") and digital communications.

Recommended or required reading:

- S. Boyd and L. Vandenberghe, "Convex Optimization". Cambridge, U.K., Cambridge Univ. Press, 2004.
- The course reader, homework with solutions, and other material by Prof. S. Boyd are available on his web page: http://web.stanford.edu/class/ee364a/
- The video lectures by Prof. S. Boyd are available on YouTube: https://www.youtube.com/watch?v=McLq1hEq3UY&list=PL3940DD956CDF0622
- IEEE journal papers related to convex optimization and its applications.

Assessment methods and criteria:
521392S: written exams 50%, homework 25%, and final project 25%; 522010J: written exams 40%, homework 20%, and final project 40%. A passing grade is required for each of the assessment items (exam, homework, and final project).

- Written exam. The written exam consists of either two mid-term exams or one final exam (no notes and no book allowed).
- Homework. All the homework assignments must be completed. The students are allowed, and even encouraged, to work in small groups, but each student is required to write and submit his /her own homework.
- Final project. The topic of the final project must be agreed upon between the teachers and the students by 31/01/2021 (it is each student's responsibility to contact the teachers before this date). The final project must be completed by 31/05/2021.
    - PhD and Master's students that are already involved in research are required to propose a topic related with their current research work.
    - Other Master's students will be assigned a topic by the teachers.

Grading:
(1-5).
Person responsible:

- Teachers: Italo Atzeni and Antti Tölli
- Teaching assistants: Bikshapathi Gouda and Hamidreza Bakshad Mahmoodi

Working life cooperation:
No
Other information:
The course content, F2F lectures, self-lectures, homework, and written exams are the same for 521392S (7 ECTS credits) and 522010J (10 ECTS credits). A larger and more involved project work is required for 522010J with respect to 521392S.

- The first period focuses on the basic theoretical aspects and consists of self-lectures and F2F lectures (one per week).
    - Self-lectures. The students are required to watch a video lecture by Prof. S. Boyd, aided by the corresponding material.

- F2F lectures. It consists of a recap of the self-lecture with questions from the students, as well as practical examples and exercises.
- The second period focuses on high-level algorithmic aspects and relevant applications, and consists of F2F lectures (two per week).

521042S: Creative Design, 5 op

Voimassaolo: 01.08.2018 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Computer Science and Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Georgi Georgiev

Opintokohteen kielet: 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:
-
Other information:
Course work space can be found from University of Oulu Moodle platform moodle.oulu.fi.

811312A: Data Structures and Algorithms, 5 op

Voimassaolo: 01.08.2010 -

Opiskelumuoto: Intermediate Studies

Laji: Course

Vastuuyksikkö: Information Processing Science DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Juustila, Antti Juhani

Opintokohteen kielet: Finnish

Leikkaavuudet:

521144A Algorithms and Data Structures 6.0 op

ECTS Credits:
5 ECTS credits / 133 hours of work.
Language of instruction:
Finnish
Timing:
The course is held in the autumn semester, during period 2. It is recommended to complete the course in the 2nd autumn semester of the Bachelor's studies.
Learning outcomes:
After completing the course the student will be able to:
* select data structures and algorithms to an application,
* apply induction when proving algorithm correctness and define recursive algorithms,
* describe trees, graphs and their basic algorithms and apply them in a program,
* describe the most common sorting algorithms, as well as
* analyse the correctness and time complexity of an algorithm implemented in a program.
Contents:
* Basic data structures
* Analysis of algorithms
* Sorting algorithms
* Hash tables
* Binary search trees
* Graphs and their algorithms
* Algorithm design paradigms
Mode of delivery:
Face-to-face teaching.
Learning activities and teaching methods:
Lectures 48 h, exercises 21 h, exercise work 27 h, independent study 39 h.

Target group:
BSc students.
Prerequisites and co-requisites:
The required prerequisite is that the learning outcomes of the following courses are accomplished: Databases

Recommended optional programme components:

Recommended or required reading:
Cormen, Leiserson, Rivest, Stein: Introduction to algorithms, Second edition, MIT Press 2001 (or newer) and other material defined during the course.

Assessment methods and criteria:
1. Exam and assignment OR 2. Mid-term exams (2) and assignment
Grading:
Numerical scale 1-5 or fail.
Person responsible:
Antti Juustila

521153S: Deep Learning, 5 op

Voimassaolo: 01.08.2019 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Computer Science and Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Li Liu

Opintokohteen kielet: English

ECTS Credits:
5 ECTS credits/135 hours of work
Language of instruction:
English
Timing:
autumn, period 2
Learning outcomes:
Upon completion of this course, the students will be able to:

1. learn the theories, models, algorithms, implementation and recent progress of deep learning, and obtain empirical experience on training deep neural networks.
2. will learn about linear classifiers, multilayer neural networks, back propagation and stochastic gradient descent, convolutional neural networks, recurrent neural networks, generative adversarial networks, deep network compression, deep transfer learning techniques and deep reinforcement learning (tentative).
3. know about applications of deep learning to typical computer vision problems such as image classification, object detection and segmentation.
4. learn to implement, train and debug their own neural networks with PyTorch.

Contents:
Students should be comfortable taking derivatives and understanding matrix vector operations and notations. Basic Probability and Statistics, Linear Algebra, basics of probabilities, Gaussian distributions, mean, standard deviation, etc.
have knowledge of Machine Learning course and digital image processing course

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.

521337A: Digital Filters, 5 op

Opiskelumuoto: Intermediate Studies

Laji: Course

Vastuuyksikkö: Computer Science and Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Olli Silven

Opintokohteen kielet: Finnish

Leikkaavuudet:

ay521337A Digital Filters (OPEN UNI) 5.0 op

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 f

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:
1. Sampling theorem, aliasing and imaging, 2. Discrete Fourier transform, 3. Z-transform and frequency response, 4. Correlation and convolution, 5. Digital filter design, 6. FIR filter design and realizations, 7. IIR filter design and realizations, 8. Finite word length effects and analysis, 9. Multi-rate signal processing.
Mode of delivery:
Online teaching (Lectures), independent work, group work
Learning activities and teaching methods:
Online 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:
Lecture notes and exercise materials. Material is in Finnish and in English. Course book: Ifeachor, E., Jervis, B.: Digital Signal Processing, A Practical Approach, Second Edition, Prentice Hall, 2002.
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.
Other information:
Course work space can be found from University of Oulu Moodle platform moodle.oulu.fi.
Open University students enroll for studies through an open website.

521467A: Digital Image Processing, 5 op

Voimassaolo: 01.08.2012 -

Opiskelumuoto: Intermediate Studies

Laji: Course

Vastuuyksikkö: Computer Science and Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Heikkilä, Janne Tapani

Opintokohteen kielet: Finnish

Leikkaavuudet:

ay521467A Digital Image Processing (OPEN UNI) 5.0 op

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:
1. Introduction
2. Fundamentals of digital image
3. Intensity transformations and spatial filtering
4. Image processing in frequency domain
5. Restoration
6. Color image processing
7. Wavelets and multi-scale processing
8. Compression
9. Morphological image processing
10. Segmentation

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:
521141P Elementary Programming or equivalent Python programming skills.
Recommended optional programme components:
None.
Recommended or required reading:
Gonzalez, R.C., Woods, R.E.: Digital Image Processing, Third Edition, Prentice-Hall, 2008, Chapters 1-10.
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.
Other information:
Course is in Moodle: https://moodle.oulu.fi/course/view.php?id=6840

812352A: Digitalisation and Innovation, 5 op

Voimassaolo: 01.08.2020 -

Opiskelumuoto: Intermediate Studies

Laji: Course

Vastuuyksikkö: Information Processing Science DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Piiastiina Tikka

Opintokohteen kielet: English

ECTS Credits:
5 ECTS credits / 133 hours of work
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 spring semester of the Master's studies
Learning outcomes:
After completing the course, the student will be able to:
* identify and describe what is digitalisation and why it is happening,
* describe how information systems and digitalisation are connected,
* build an overview of organisational/enterprise information systems,
* describe the role of emerging technologies in the society,
* form an overview and describe how innovation takes place, particularly in IT, as well as
* identify opportunities and challenges of future technologies.
Contents:
* 1. What is digitalisation? What is digital transformation? Why digitalisation?
* 2. Information systems and digitalisation
* 3. Organisational information systems
* 4. The role of emerging technologies
* 5. The quest for disruptive Zero-to-One innovation
* 6. Core business values
* 7. Innovation strategies and innovation ecosystems
* 8. Opportunities and challenges of future technology
Mode of delivery:
Face-to-face teaching
Learning activities and teaching methods:
Lectures and interactive / hands-on exercises, course assignment (design task)
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 Information Systems.
Recommended or required reading:
"Oinas-Kukkonen H. & Oinas-Kukkonen H.: Humanizing the Web: Change and Social Innovation. Palgrave Macmillan, Basingstoke, UK, 2013. Chapters 7-12.
Other reading matter, to be announced during the course."
Assessment methods and criteria:
Exam
Grading:
Numerical scale 1-5 or fail
Person responsible:
Harri Oinas-Kukkonen

521290S: Distributed Systems, 5 op

Voimassaolo: 01.08.2015 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Computer Science and Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Teemu Leppänen

Opintokohteen kielet: Finnish

Leikkaavuudet:

521266S-01 Distributed Systems, Exam 0.0 op

521266S-02 Distributed Systems, Exercise Work 0.0 op

521266S Distributed Systems 6.0 op

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:
Online teaching
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:
Required literature: Maarten van Steen and Andrew S. Tanenbaum, Distributed Systems – Principles and Paradigms, Third Edition, 2017.
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.

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

Grading:
Numerical scale 1-5; zero stands for a fail.
Person responsible:
Teemu Leppänen
Working life cooperation:
None.
Other information:
Course work space can be found from University of Oulu Moodle platform moodle.oulu.fi.

521115S: EMC Design, 5 op

Voimassaolo: 01.08.2005 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Electrical Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Hannu Sorvoja

Opintokohteen kielet: Finnish

Leikkaavuudet:

521172S EMC Design 4.0 op

521172S-02 EMC Design, Exercise work 0.0 op

521172S-01 EMC Design, Exam 0.0 op

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:
Tim Williams: EMC for Product Designers, 5th edition, Oxford: Newnes, 2017. Lecture slides.
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:
-

521038A: Electrical Engineering Project Studies, 1 - 5 op

Voimassaolo: 01.01.2018 -

Opiskelumuoto: Intermediate Studies

Laji: Course

Vastuuyksikkö: Electrical Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Jari Hannu
Opintokohteen kielet: Finnish

Ei opintojaksokuvauksia.

521039A: Electrical Engineering Project Studies 2, 1 - 5 op

Voimassaolo: 01.01.2018 -
Opiskelumuoto: Intermediate Studies
Laji: Course
Vastuuyksikkö: Electrical Engineering DP
Arvostelu: 1 - 5, pass, fail
Opettajat: Jari Hannu
Opintokohteen kielet: Finnish

Ei opintojaksokuvauksia.

521109A: Electrical Measurement Principles, 5 op

Opiskelumuoto: Intermediate Studies
Laji: Course
Vastuuyksikkö: Electrical Engineering DP
Arvostelu: 1 - 5, pass, fail
Opettajat: Christian Schuss
Opintokohteen kielet: 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:
Christian Schuss
Working life cooperation:
None.
Other information:
-

521092A: Electronic Measurement Techniques, 5 op

Voimassaolo: 01.08.2015 -

Opiskelumuoto: Intermediate Studies

Laji: Course

Vastuuyksikkö: Electrical Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Christian Schuss

Opintokohteen kielet: Finnish

Leikkaavuudet:

521171A	Electronic Measurement Techniques	6.5 op
521171A-01	Electronic measurement techniques, exam	0.0 op
521171A-02	Electronic measurement techniques, exercise work	0.0 op
521430A	Electronic Measurement Techniques	6.0 op

ECTS Credits:
5 ECTS credits / 132 h
Language of instruction:
In Finnish or in English if two or more foreign students participate.
Timing:
Period 4 academic year 20-21 and 21-22. Period l from academic year 22-23 forward.
Learning outcomes:
1. remembers the electrical measurement technique terminology associated to measurement systems, sensors and buses.
2. can name most important analog signal conditioning structures
3. can plan and implement basic measurements with electrical thermometers
4. can plan and implement basic measurements with optical meters
5. can name common sources of noise and interference and means to control them
6. 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 28h and self-study 100h.
Target group:
Course is compulsory for electrical engineering students. Course is open for all students in University of Oulu.
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 Moodle.
Assessment methods and criteria:
The course is passed with a final exam.

Grading:
Numerical grading scale 1-5.
Person responsible:

Christian Schuss
Working life cooperation:
None.
Other information:
-

521124S: Electronic Sensors, 5 op

Opiskelumuoto: Advanced Studies
Laji: Course
Vastuuyksikkö: Electrical Engineering DP
Arvostelu: 1 - 5, pass, fail
Opettajat: Aliaksandr Bykau, Alexey Popov
Opintokohteen kielet: 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.
The information about the course 521124S - Anturit ja mittausmenetelmät/Electronic Sensors has been added to the Moodle page:
https://moodle.oulu.fi/course/view.php?id=5357

Course description: "The course is aimed at students willing to be capable of explaining the operating principles of different sensors and selecting the right sensor for each measuring target. We will focus on how to quantify the requirements that affect sensor selection as well as recognize and evaluate the uncertainty of a measurement. In addition, we will go into questions on how to plan and design sensor signal conditioning circuits."

The lectures and seminars will be organized remotely via Zoom environment. The corresponding link will be published on the page of the course in Moodle prior to the lecture.
Target group:
4 year students.
Prerequisites and co-requisites:
No.
Recommended optional programme components:
No.
Recommended or required reading:
H. N. Norton: Handbook of Transducers, Prentice Hall P T R, 1989 or 2002; lecture and exercise notes.
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.

521405A: Electronic System Design, 5 op

Opiskelumuoto: Intermediate Studies
Laji: Course
Vastuuyksikkö: Electrical Engineering DP
Arvostelu: 1 - 5, pass, fail
Opettajat: Kari Määttä
Opintokohteen kielet: 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:
Lecture notes. Ward & Angus: Electronic Product Design, Hall&Hall&McCall: High speed Digital Design, Montrose: EMC and the Printed Circuit Board, Ott: Noise Reduction Techniques. Eric Bogatin: Signal and Power Integrity – Simplified, 2. ed.
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:
-

521401S: Electronics Design II, 6 op

Voimassaolo: 01.08.2017 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Electrical Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Ilkka Nissinen

Opintokohteen kielet: English

Leikkaavuudet:

521443S Electronics Design II 5.0 op

ECTS Credits:
6 ECTS
Language of instruction:
In Finnish (In English if needed).
Timing:
Autumn, period 1
Learning outcomes:
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 20h. Learning without guidance either privately or in a group 60h.
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:
Lecture handout,T. C. Carusone, D. A. Johns & K.W. Martin: Analog integrated circuit design , Wiley cop. 2012. 2nd ed., chapters 1, 3, 6, 9, 10, 15, 16 and 17, parts of 4 ja 11; P.E. Allen & D.R. Holberg: CMOS Analog Circuit Design, Oxford University Press 2002, chapters 1,3,4,5, 6, 8 and 10.
Assessment methods and criteria:
The course unit is passed by a final exam 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:
-
Other information:
-

521435S: Electronics Design III, 6 op

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Electrical Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Ilkka Nissinen

Opintokohteen kielet: 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; Self-study or in a group of two persons: laboratory exercise 40 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.
The course is organized remotely and Zoom links for lectures and exercises can be found from Moodle under the topics lectures and exercises.
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: D. A. Johns & K. Martin: Analog integrated circuit design, Wiley & Sons 1997 chapter 6, chapter 8 partially, 9, 10, 14, 15 and 2. Also P. E. Allen & D. R. Holberg: CMOS Analog Circuit Design, Oxford university press 2002, chapters 2, 7, and 9, proper parts of other chapters of the book.
Assessment methods and criteria:
Passed final exam 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:
-
Other information:
-

521300S: Electronics Design and Construction Exercise, 6 op

Voimassaolo: 01.08.2015 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Electrical Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Kari Määttä

Opintokohteen kielet: Finnish

Leikkaavuudet:

521441S Electronics Design and Construction Exercise 6.5 op

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

521275A: Embedded Software Project, 8 op

Voimassaolo: 01.08.2007 -

Opiskelumuoto: Intermediate Studies

Laji: Course

Vastuuyksikkö: Computer Science and Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Teemu Tokola

Opintokohteen kielet: English

ECTS Credits:
8
Language of instruction:
Material in English, lectures and guidance of individual groups available in English.
Timing:
Spring, periods 3-4.
Learning outcomes:
1. Can work independently on a non-trivial problem

2. Knows how to write a thesis and has gained lot of experience on refining text

3. Can make a scientific background study on a topic

4. Has increased experience on implementing an embedded software

5. Has improved group work and project skills
Contents:
This course familairizes the student with modern embedded system development with modern methods and tools. Topics: Development tools, practical application program for an embedded system. The students additionally work on the application topic through scientific papers and use their application program to produce a scientific work of their own.
Mode of delivery:
Remote teaching, guidance meetings and independent project work in groups.

Learning activities and teaching methods:
Pair project with monitoring meetings and a compulsory exercise. Lectures 30 h, design exercise in period 3-4 180 h.
Target group:
Computer Science and Engineering students and other Students of the University of Oulu.
Prerequisites and co-requisites:
521457A Software Engineering, 521286A Computer Systems or 521142A Embedded Systems Programming. In addition, 521453A Operating Systems be beneficial.
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:
Course website, hardware data sheets and manuals, scientific publications.
Assessment methods and criteria:
Project report and a demonstrated implementation.
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 Tokola
Working life cooperation:
The topics of the course are relevant research topics with applications in the industry, and visiting lecturers are occasionally arranged to shed light on how the course topics are applied in the industry.
Other information:
The 521275A course offers the possibility to complete your Bachelor thesis in a structured course environment. The course is suitable also for students who do not use the course for their Bachelor Thesis.
Course work space can be found from University of Oulu Moodle platform: https://moodle.oulu.fi/course/view.php?id=5927.

521423S: Embedded System Project, 5 op

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Computer Science and Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Teemu Tokola

Opintokohteen kielet: 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:
Online teaching. Lectures, 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.

812351A: Enterprise Systems, 5 op

Voimassaolo: 01.08.2015 -

Opiskelumuoto: Intermediate Studies

Laji: Course
Vastuuyksikkö: Information Processing Science DP
Arvostelu: 1 - 5, pass, fail
Opettajat: Nataliya Shevchuk
Opintokohteen kielet: English

ECTS Credits:
5 ECTS credits / 133 hours of work.
Language of instruction:
English
Timing:
The course is held in the autumn semester, during period 2. It is a recommended to compelete the course at the 2nd autumn semester of the Master's studies.
Learning outcomes:
After completing the course, the student understands Enterprise Resource Planning (ERP), Supply Chain Management (SCM), Inventory
Management, CRM, Knowledge Management, Online Business systems, Marketing systems, etc., and also understands the intellectual capital and organizational competitive advantage. The student should be able to describe how processes integrate the internal functions of the firm and allow the firm to interact with its environment, and be able to recognize, model, and improve processes to help the firm achieve efficiency and effectiveness.
Contents:
* 1. Principles of enterprise systems, and business processes that integrate the internal functions of the enterprise and connect the enterprise with its business environment;
* 2. Manage enterprises' intellectual capital to achieve competitive advantage;
* 3. Enterprise resource planning (ERP);
* 4. Supply chain management (SCM);
* 5. Global supply chain & inventory management systems
* 6. Knowledge management systems;
* 7. Customer relationship management (CRM);
* 8. Internet-based Business and Marketing Systems;
* 9. Enterprise application integration (EAI)
Mode of delivery:
Face-to-face teaching
Learning activities and teaching methods:
Lectures 20h, exercises 8h, independent work 105h (supplementary essays and final exam)
Target group:
MSc students
Prerequisites and co-requisites:
Understanding of the business process modeling helps.

Recommended optional programme components:

Recommended or required reading:
Research articles and other materials to be provided during the course
Assessment methods and criteria:
Exam
Grading:
Numerical scale 1-5 or fail.
Person responsible:
Michael Oduor

521292S: Fundamentals of Sensing, Tracking and Autonomy, 5 op

Voimassaolo: 01.08.2020 -
Opiskelumuoto: Advanced Studies
Laji: Course
Vastuuyksikkö: Computer Science and Engineering DP
Arvostelu: 1 - 5, pass, fail

Opettajat: Steven LaValle

Opintokohteen kielet: English

ECTS Credits:
5 ECTS credits / 135 hours of work.
Language of instruction:
Primary instruction language is English.
Timing:
The course is held in the spring semester, during period III. It is recommended to complete the course at the 4rd spring semester.
Learning outcomes:
Upon completion of the course the students will be able to:

- Deeply understand the fundamentals common to widely used sensing and filtering systems.
- Design new sensors and filters.
- Apply the material to critical problems in robotics, internet of things, and virtual and augmented reality.
- Understand the links between theory and practice in sensing and filtering systems.

Contents:
Defining sensors; physical vs virtual sensors. Chronometers, cameras, infrared, laser, temperature, IMU. Sensor mappings, resolution, noise, calibration. Preimages, sources of uncertainty, comparing sensors, stochastic modeling. Multiple sensor readings and networks of sensors. Triangulation principles. Motion models: Discrete time, continuous time, event-based. Linear, complementary, Kalman, Bayesian, and combinatorial filters. Localization and mapping; global positioning systems; tracking humans.
Mode of delivery:
Online teaching.
Learning activities and teaching methods:
The course will consist of lectures (28h), individual homework assignments (48h), self-study (56h), final exam (3h).
Target group:
M.Sc. students in CSE, EE, and related areas.
Prerequisites and co-requisites:
Matrix Algebra (mandatory BSc 1st year); Differential Equations (mandatory BSc 1st year); Introduction to Computer Systems (mandatory BSc 2nd year); Mathematical Structures for Computer Science (mandatory BSc 2nd year).
Recommended optional programme components:
The course does not require other courses to be completed simultaneously. This course is the first part of a two-part series, in which the second part would finish tracking and cover autonomy. The course fundamentals complement parts of 521287A Introduction to Computer Systems, which provides experimental practice with sensors. The course is related to 521161S Multi-Modal Data Fusion as applied artificial intelligence, but instead has emphasis on geometric concepts and use cases derived from robotics, IoT, and VR/AR. The course has minor overlap with 521124S Sensors and Measuring Techniques, which focuses on experimentation, data collection, and sensor selection.
Recommended or required reading:
Online-material that is delivered throughout the course.
Assessment methods and criteria:
The students are assessed according to their performance in assignments and the final exam. The assessment criteria are based on the learning goals of the course.
Grading:
Numerical (1-5).
Person responsible:
Steven LaValle
Working life cooperation:
The course does not contain working life cooperation.

521145A: Human-Computer Interaction, 5 op

Voimassaolo: 01.08.2012 -

Opiskelumuoto: Intermediate Studies

Laji: Course

Vastuuyksikkö: Computer Science and Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Simo Hosio

Opintokohteen kielet: English

ECTS Credits:
5 ECTS cr
Language of instruction:
Finnish/English

Timing:
Autumn semester, Period II
Learning outcomes:
Upon completing this course, students will possess:
1. Knowledge of Human Computer Interaction (HCI) fundamentals
2. Knowledge and practical experience of user-centric computer interface and usability evaluation techniques, such as questionnaires and interviewing
3. Knowledge and experience of prototyping techniques (both paper-based as well as digital)
4. Knowledge of how HCI can be incorporated in the software development process

Contents:
Fundamental knowledge of humans, and how that relates to computer systems and interfaces. Learning design in 2-3 different ways, and conducting evaluations of the designs. Evaluation constitutes data collection and analysis, including qualitative and quantitative data.
Mode of delivery:
Online teaching (lectures), group work (labs).
Learning activities and teaching methods:
Lectures (12 h), exercises (16 h), and practical work (105 h). The course is passed with approved classroom /reading package reflections, and an approved group-based practical work (several assignments). The implementation is doable fully in 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 teamwork skills are required and the capability to provide documentation.
Recommended optional programme components:
All necessary material will be provided by the instructor.
Recommended or required reading:
No required reading.
Assessment methods and criteria:
The course completion relies on completed solo-work (reflections), and the numerical assessment is project-based. Students have to complete several individual exercises throughout the semester: ideating an application, designing various versions of its prototype, evaluating those prototypes, documenting the final application designs. Passing criteria: all stages of the project-based work must be completed, each receiving more than 50% of the available points.
Grading:
The course unit utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.
Person responsible:
Associate Professor Simo Hosio
Working life cooperation:
If relevant, guest lectures may be organized (optional).
Other information:
Using Moodle as the teaching platform: https://moodle.oulu.fi/course/view.php?id=5409

812651S: ICT and Behaviour Change, 5 op

Voimassaolo: 01.08.2011 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Information Processing Science DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Piiastiina Tikka

Opintokohteen kielet: English

ECTS Credits:
5 ECTS credits / 133 hours of work
Language of instruction:
English
Timing:
The course is held in the spring semester, during period 4. It is recommended to complete the course at the 1st spring semester of the Master's studies.
Learning outcomes:
After completing the course, the student will be able to:
* grasp the core theories of behaviour change and how they are/can be applied in goal-oriented behaviour change,
* identify and discuss ethical concerns inherent in behaviour change and persuasive systems, and
* identify and discuss the possible negative effects of ICT use not only as regards persuasive systems, but also with social media and other use.
Contents:
The focus of the course is role of ICT in supporting people with their endeavours to change their habits or lifestyles. The course introduces the main theories and models regarding behaviour change in order to provide students with a solid base for understanding how behaviour change can also work through ICT. The course also introduces some of the more problematic topics in ICT and behaviour, such as the dark side of ICT use and ethics of persuasion.
The course aims at providing existing knowledge and theoretical starting points to the development and use of persuasive systems. With such base, the student will be able to review the field from a broad perspective with the view to applying appropriate theories and approaches when analysing or developing persuasive systems.
Mode of delivery:
Face-to-face teaching
Learning activities and teaching methods:
Lectures 14 h, seminars 20 h, individual and group assignments 100 h; or in self-study mode opening lecture 2 h, assignments 132 h
Target group:
MSc students
Prerequisites and co-requisites:
The suggested prerequisite is that the learning outcomes of the following courses and their predecessors are accomplished: Persuasive Systems Design.
Recommended optional programme components:
The MSc courses "Persuasive Systems Design" and "Emerging Technologies and Issues" would be helpful, but is not required.
Recommended or required reading:
Research articles to be announced more specifcally during the course implementation
Assessment methods and criteria:
Course assignment
Grading:
Numerical scale 1-5 or fail
Person responsible:
Piiastiina Tikka
Working life cooperation:
-

817604S: ICT and Organizational Change, 5 op

Voimassaolo: 01.08.2010 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Information Processing Science DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Karin Väyrynen

Opintokohteen kielet: English

ECTS Credits:
5 ECTS credits / 133 hours of work.
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 2nd spring semester of the Master's studies.
Learning outcomes:
After completing the course, the student will able to:
* distinquish various roles of information and communication technology (ICT) in change of organization and its context, and
* analyze the role of ICT in relation with change taking place in an organization.
Contents:
The course studies organisations at four levels: individuals, practices, organizational structures and transformations, and the societal context of organisations. The organizational role of ICT and the relation between ICT and knowledge are also discussed. The role of power, trust and control in the change process is discussed. The different aspects of change agents are presented and analysed. Students familiarize themselves with 7 organizational theories.
Mode of delivery:
Face-to-face teaching.
Learning activities and teaching methods:
Lectures and case analysis sessions 28 h, individual work 105 h (for self-studying for weekly exams, and for case analyses).
Target group:
MSc students
Prerequisites and co-requisites:
Recommended to take Emerging Technologies and Issues before this course.
Recommended optional programme components:

Recommended or required reading:
A list of research articles will be provided for the lectures and assignments.
Assessment methods and criteria:
Mandatory weekly exams and case analyses
Grading:
Numerical scale 1-5 or fail.
Person responsible:
Karin Väyrynen

813623S: Information Security Policy and Management in Organisations, 5 op

Voimassaolo: 01.08.1950 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Information Processing Science DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Nataliya Shevchuk

Opintokohteen kielet: English

ECTS Credits:
5 ECTS credits / 133 hours of work.
Language of instruction:
English
Timing:
The course is held in the spring semester, during period 4. It is recommended to complete the course at the 2nd spring semester of the Master's studies.
Learning outcomes:
After completing the course, the student will be able to:
* develop BCM (Business Continuity Management) and SA (Systems Availability) strategy;
* develop organization specific information security policies in organizations;
* conduct Information Security (and risk) Analysis;
* conduct Information Security Audits;
* understand information security standards, regulations, and policies;
* improve employees’ compliance with the information security procedures through training, campaigning and other means;
* describe certifications related to information security (such as ISO27001); as well as
* describe public-key infrastructure (PKI), Digital signature, & Certification authority (CA).

Contents:
* Business Continuity Management (BCM) and Systems Availability (SA)
* Information Security Life Cycle
* Conduct Information Security (and risk) Analysis;
* Information security standards, regulations, and policies
* Information security investment management
* Insider threats in information security management
* Security Audits (Active Security Assessment)
* Information Security Certification (ISO27001) & Certification authority (CA)

Mode of delivery:
Blended teaching
Learning activities and teaching methods:
Lectures (24 h), exercises (23 h), learning diary (30 h), essay (20 h), examination (36 h)
Target group:
MSc students
Prerequisites and co-requisites:
Understanding of information security issues, principles, techiniques, or similar knowledge, is helpful.
Recommended or required reading:
Research articles to be announced more specifcally during the course implementation.
Assessment methods and criteria:
Examination.
Grading:
Numerical scale 1-5 or fail.
Person responsible:
Nataliya Shevchuk

521390S: Information Theory, 5 op

Voimassaolo: 01.08.2019 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Electrical Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Markus Leinonen, Hirley Alves

Opintokohteen kielet: English

ECTS Credits:
5
Language of instruction:
English
Timing:
Fall, period 1, will be lectured on even years (2020, 2022, ...)
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
Thomas M. Cover & Joy A. Thomas: Elements of Information Theory, 2nd ed. John Wiley & Sons, 2006 ISBN-13 978-0-471-24195-9, ISBN-10 0-471-24195-4,
Raymond W. Yeung, Information Theory and Network Coding, Springer; 2008 edition, ISBN-13: 978-0387792330
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.

521043S: Internet of Things, 5 op

Voimassaolo: 01.08.2018 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Computer Science and Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Ella Peltonen

Opintokohteen kielet: English

Proficiency level:

Status:

ECTS Credits:
5 ECTS / 135 hours of work

Language of instruction:
English

Timing:
Autumn semester during period 2.

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:
The course will be given fully remotely. Please join the Moodle page (https://moodle.oulu.fi/course/view.php?id=5330, password is iot2020) and attend the introduction Zoom lectures in Tue 27.10. 10:15-12 (for general organisation) and Wed 28.10. 14:15-16 (for course project).

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.

521242A: Introduction to Biomedical Engineering, 5 op

Voimassaolo: 01.08.2017 -
Opiskelumuoto: Intermediate Studies
Laji: Course
Vastuuyksikkö: Electrical Engineering DP
Arvostelu: 1 - 5, pass, fail
Opettajat: Teemu Myllylä
Opintokohteen kielet: 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:
-

521079S: Introduction to Nanotechnology, 5 op

Voimassaolo: 01.08.2015 -
Opiskelumuoto: Advanced Studies
Laji: Course
Vastuuyksikkö: Electrical Engineering DP
Arvostelu: 1 - 5, pass, fail
Opettajat: Krisztian Kordas
Opintokohteen kielet: 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 nanomaterials. Properties on the nanoscale. Integration and device development with nanomaterials. Current and future applications.
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:
Lecutre notes and parts of following books Springer Handbook of Nanotechnology, (Ed.) B. Bhushan. Springer Handbook of Nanomaterials, (Ed.) R. Vajtai. Nano-Age: How Nanotechnology Changes Our Future, M. Pagliaro. Applied Nanotechnology: The Conversion of Research Results to Products, J. Ramsden. Introduction to Nanotechnology, C.P. Poole, Jr.,F.J. Owens.
Assessment methods and criteria:
Examination.
Grading:
Numerical grading 1-5.
Person responsible:
Krisztian Kordas
Working life cooperation:
-
Other information:
-

031025A: Introduction to Optimization, 5 op

Opiskelumuoto: Intermediate Studies

Laji: Course

Vastuuyksikkö: Applied Mathematics and Computational Mathematics

Arvostelu: 1 - 5, pass, fail

Opettajat: Ruotsalainen Keijo

Opintokohteen kielet: 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.
The course, Introduction to Optimization, will be lectured remotely through the ZOOM video conferencing tool. The more detailed instructions and access to ZOOM lectures can be found in the Moodle work space of the course. The link is here: https://moodle.oulu.fi/course/view.php?id=5350.
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:
The course, Introduction to Optimization, will be lectured remotely through the ZOOM video conferencing tool. The more detailed instructions and access to ZOOM lectures can be found in the Moodle work space of the course. The link is here: https://moodle.oulu.fi/course/view.php?id=5350.

521157A: Introduction to Social Network Analysis, 5 op

Voimassaolo: 01.08.2017 -

Opiskelumuoto: Intermediate Studies

Laji: Course

Vastuuyksikkö: Computer Science and Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Mourad Oussalah

Opintokohteen kielet: English

ECTS Credits:
5 ECTS credits / 120 hours of works
Language of instruction:
English
Timing:
Period 4. It is recommended to complete the course at the end of period 4
Learning outcomes:
Upon completing the course, the student is expected to i) understand social aspects of the web; ii) learn to collect, clean and represent social media data; iii) quantify important properties of social media; iv) find and analyze (online) communities; v) understand the diffusion process in social network; vi) familiarize with simple modelling toolkits for social media analysis
Contents:
The course describes basics of social network analysis, allowing the students to understand structure and evolution of the network, while enabling them to use appropriate tools and techniques to draw inferences and discover hidden patterns from the network. The course is designed to accommodate computer science, mathematical and social science student background, which helps in emergence of multi-disciplinary research in the university
Mode of delivery:
Face- to-face teaching and laboratory sessions
Learning activities and teaching methods:
Lectures (24 h), tutorial/laboratory sessions (12h), seminar (6 h) 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 logical reasoning skills
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:
R. Zafarani, M. A. Abbasi, and H. Liu, Social Media Mining: An Introduction, Cambridge University Press, 2014
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:
-
Other information:
We hope to attract students from humanties, economics and political in order to encourage multidisciplinary studies and enforce interesting student projects where each group contains at least one student from computer science and one from another faculty.

521293A: Introduction to XR Systems, 5 op

Voimassaolo: 01.08.2020 -

Opiskelumuoto: Intermediate Studies

Laji: Course

Vastuuyksikkö: Computer Science and Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Paula Alavesa

Opintokohteen kielet: English

ECTS Credits:
5 ECTS credits / 135 hours of work.
Language of instruction:
Primary instruction language is English.

Timing:
The course is held in the spring semester, during period III. It is recommended to complete the course at the 3rd spring semester.
Learning outcomes:
Upon completion of the course the students will be able to:

- Recall all of the components of modern XR systems
- Understand the interaction between the hardware, software, and human senses during an XR experience.
- Understand how the choices in hardware and software components influence human perception and the quality of XR experiences.
- Identify challenges facing next generation XR systems.
- Develop a basic VR experience using Unity3D.

Contents:
Overview of XR hardware: projectors, screens, light field displays, retinal scanners, waveguides. Overview of XR systems software: rendering systems and methods (gaming engines, panoramas, telepresence) tracking systems and methods (inside-out and inside-in tracking, camera-based methods, lighthouse, natural and artificial markers, IMU integration, sensor fusion. High level overview of human physiology, neuroscience, and human perception in relation to XR hardware and software.
Mode of delivery:
Online
Learning activities and teaching methods:
The course will consist of lectures (28h), individual lab exercises (28h), solo project (28h), self-study (48h), online final exam (3h). Students can borrow equipment from the lab to minimize the need for lab attendance. It is also possible, in small groups (<10), to do the exercise in the lab, however we aim to minimize any need for face to face teaching with other arrangements.
Target group:
B.Sc. students in all areas, especially applied computing and human sciences.
Prerequisites and co-requisites:
No prerequisites.
Recommended optional programme components:
The course is an independent entity, and does not require other additional studies carried out at the same time. It can also be considered as the first in the set of courses on VR and XR. It should be taken before VR Systems and Humans course (521291S) and 3D environments and Applications (521040A).
Recommended or required reading:
Online-material that is delivered throughout the course.
Assessment methods and criteria:
The students are assessed according to their performance in assignments, in-lecture quizzes, final project, and the final exam. The assessment criteria are based on the learning goals of the course.
Grading:
Numerical (0-5). In the numerical scale zero stands for a fail.
Person responsible:
Anna LaValle.
Working life cooperation:
When possible, a guest lecture will be held by a visitor from a VR company.

521289S: Machine Learning, 5 op

Voimassaolo: 01.08.2015 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Computer Science and Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Tapio Seppänen

Opintokohteen kielet: Finnish

Leikkaavuudet:

521497S-01	Pattern Recognition and Neural Networks, Exam	0.0 op
521497S-02	Pattern Recognition and Neural Networks; Exercise Work	0.0 op
521497S	Pattern Recognition and Neural Networks	5.0 op

ECTS Credits:

5 ECTS credits.
Language of instruction:
English.
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 regression techniques to practical machine learning problems.

Contents:
Introduction. Bayesian decision theory. Parametric and non-parametric classification. Feature extraction. Classifier design and optimization. Example classifiers. Statistical regression methods.
Mode of delivery:
Online teaching, guided laboratory work and independent assignment. The laboratory works are done on an online system (Mathworks Grader). Student can do the lab works remotely or in the lab using the same online system.
The course is implemented as remote education via the Moodle work space https://moodle.oulu.fi/course/view.php?id=5729
This work space opens to students before the course begins. The student must register to the course in WebOodi in order to participate the course.
Learning activities and teaching methods:
Lectures 16 h, Laboratory work 16 h, and Self-study the rest (Independent task assignment).
Target group:
Students who are interested in machine learning and pattern recognition theory and methods.
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:
Will be informed when the course starts.
Assessment methods and criteria:
Laboratory work is supervised by assistants who also verify that the task assignments are completed properly. The Matworks Grader online system also verifies the completed tasks. The independent task assignment is graded which establishes the grade for the course.
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 the independent task assignment.
Person responsible:
Tapio Seppänen
Working life cooperation:
No

521466S: Machine Vision, 5 op

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Computer Science and Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Heikkilä, Janne Tapani

Opintokohteen kielet: 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:
1. Introduction, 2. Imaging and image representations, 3. Light and color, 4. Binary image analysis, 5. Texture, 6. Local features, 7. Recognition, 8. Motion, 9. 2D models and transformations, 10. Perceiving 3D from 2D images, 11. 3D transformations and reconstruction.
Mode of delivery:
Online lectures and exercises, homework assignments.
Learning activities and teaching methods:
Lectures (24 h), exercises (16 h) and programming assignments (32 h), self-studying (61 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:
Lecture slides and exercise material. The following books are recommended for further information: 1) Shapiro, L. G. & Stockman, G.C.: Computer Vision, Prentice Hall, 2001. 2) Szeliski, R.: Computer Vision: Algorithms and Applications, Springer, 2011. 3) Forsyth, D.A. & Ponce, J.: Computer Vision: A Modern Approach, Prentice Hall, 2002.
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.
Other information:
Course is in Moodle: https://moodle.oulu.fi/course/view.php?id=4317

521096S: Measurement Systems, 5 op

Voimassaolo: 01.08.2015 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Electrical Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Christian Schuss

Opintokohteen kielet: Finnish

Leikkaavuudet:

521110S	Measuring and Testing Systems	6.0 op
521110S-01	Measuring and Testing Systems, exam	0.0 op
521110S-02	Measuring and Testing Systems, exercise work	0.0 op

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 Moodle.
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:
Christian Schuss
Working life cooperation:
No.

521075S: Microelectronics Packaging Technologies, 5 op

Voimassaolo: 01.08.2015 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Electrical Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Sami Myllymäki

Opintokohteen kielet: 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 radio electronics will be migrate towards circuit board and components on it.

Contents:
Radio technology applications are emphasized. Trends of packaging and component technologies. Area array packaging techniques. BGA-components. Micro joining and bonding. Multi-chip-modules: MCM-L, MCM-D and MCM-C modules. Fine line techniques. System level packaging (SOC, SOP). Multilayer substrates and integration of passive components. 3-D packaging. radio electronics modules. MEMS components. Electronics applications to nanotechnology.

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:
Rao R. Tummala(edit): Fundamentals of microsystems packaging, New York, McGraw-Hill, 2001. R.R. Tummala and M. Swaminathan, Introduction to System-on-Package (SOP), McGraw-Hill, 2008.

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 op

Voimassaolo: 01.08.2015 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Electrical Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Krisztian Kordas

Opintokohteen kielet: English

Leikkaavuudet:

521224S	Microelectronics and Micromechanics	6.0 op
521224S-01	Microelectronics and Micromechanaics, exam	0.0 op
521224S-02	Microelectronics and Micromechanics, exercise	0.0 op

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 nanopartciles 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:
-

521215S: Microelectronics project, 5 op

Voimassaolo: 01.08.2017 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Electrical Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Jari Juuti

Opintokohteen kielet: 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, durin periods 3 and 4. It is recommended to complete the course at the 4^{th} 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:
-

521072S: Microsensors, 5 op

Voimassaolo: 01.08.2015 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Electrical Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Jari Hannu

Opintokohteen kielet: Finnish

Leikkaavuudet:

521228S Microsensors 4.0 op

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 electronics and communications 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:
-

521046A: Mobile Computing, 5 op

Voimassaolo: 01.08.2020 -

Opiskelumuoto: Intermediate Studies

Laji: Course

Vastuuyksikkö: Computer Science and Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Aku Visuri

Opintokohteen kielet: English

Leikkaavuudet:

521045S	Mobile Computing	5.0 op
521147S	Mobile and Social Computing	5.0 op

ECTS Credits:
5 ECTS credits / 138 hours of work
Language of instruction:
English
Timing:
The course is held in the spring semester, during period 3.
Learning outcomes:
This course focuses on one of the core demands of the industry today: an understanding of mobile user interaction, computing constraints, an introduction to mobile development (Android) covering multiple aspects of the platform. This is a 5 ECTS course, with both lectures and practical sessions (labs).
After this class, students can:

- design and prototype a mobile user interface taking into account usability aspects of interaction on smaller displays
- explain and leverage the fundamental concepts of context-awareness using smartphone hardware, software and human sensors
- understand and implement from scratch a mobile application that leverages both usability and context to create engaging mobile experiences
- use GitHub for managing mobile application development.

Contents:
Lecture 1: Introduction to Mobile Computing
Lecture 2: Interacting with the user
Lecture 3: Introduction to Kotlin
Lecture 4: Sensing the world

Lecture 5: Multitasking on the go
Lecture 6: Context-aware mobile services
Lecture 7: Multimodal interaction: voice, touch, haptic, vision
Mode of delivery:
Remote teaching (online lectures and online 1-on-1 help if required)
Learning activities and teaching methods:
This course leverages on the iterative learning protocol. Students will iterate a pre-determined app, which they will develop independently at home. Guidance will be provided in the lab sessions. In each iteration, feedback is given to improve the followed implementation and we collaboratively learn in the process. A grade is given (0-100%, a pass is 50%) on how much was successfully implemented by the student at the end of Period 3-
Target group:
Computer Science and Engineering students and others related (ICT)
Prerequisites and co-requisites:
Recommended to have experience with object-oriented programming (Java, Python, C#, etc).
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:
This course utilizes a continuous assessment. During the course there are 5 homework assignments during Period 3 and 7 Lecture assignments which grant points (max 100) towards course completion. 50 points are required for a passing grade.
Grading:
The course utilizes a numerical grading scale 0-5. In the numerical scale zero stands for a fail.
Person responsible:
Aku Visuri
Working life cooperation:
The course does not contain working life cooperation.
Other information:
Course is in Moodle
https://moodle.oulu.fi/course/view.php?id=6195

521318S: Modern Topics in Telecommunications and Radio Engineering, 3 - 7 op

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Electrical Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Jari Iinatti

Opintokohteen kielet: English

Voidaan suorittaa useasti: Kyllä

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:
1 st and 2 nd 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:
Jari Iinatti
Working life cooperation:
-
Other information:
-

521161S: Multi-Modal Data Fusion, 5 op

Voimassaolo: 01.08.2017 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Computer Science and Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Jaakko Suutala

Opintokohteen kielet: English

ECTS Credits:
5 ECTS cr / 135 hours of work
Language of instruction:
English
Timing:
Autumn / period 2.
Learning outcomes:
Upon completion of the course, the student will be able to

1. understand the problem of combining data of different natures and coming from different sources
2. explain basic principles of combining multi-sensor data
3. know the common types of data fusion techniques
4. understand and utilize Bayesian probabilistic reasoning framework in multi-modal data fusion
5. understand basic principles of machine learning applied to multi-modal data fusion
6. 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. We will be concentrated on defining general statistical framework for multi-modal data processing. Using this framework, we will show concepts of common representation and alignments, sequential Bayesian inference, and machine learning approaches to data fusion as well as specific models and algorithms in each category. Furthermore, the course will illustrate many real-life examples taken from a diverse range of applications to show how they can be benefitted from data fusion approaches.
The course will discuss the following topics:

1. Introduction
2. Sensors and architectures

3. Common representation
4. Alignments
5. Bayesian inference and probabilistic reasoning
6. Sequential Bayesian inference
7. Bayesian Decision Theory and ensemble learning
8. Advanced topics

Mode of delivery:
The course will be based on a combination of lectures (face-to-face teaching), exercises, and a final project.
Learning activities and teaching methods:
16 h lectures, 16 h exercises (including programming tasks), 35 h final programming project, home study.
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:
The course will be self-contained as much as possible (i.e., no previous knowledge of multi-sensor data fusion is assumed). Basic knowledge on mathematics and statistics as well as related topics like signal processing, and machine learning will be a plus.
The required prerequisite is the completion of the following courses: 031078P Matrix Algebra, 031021P Probability and Mathematical Statistics, 521156S Towards Data Mining, and 521289S Machine Learning.

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 will be based on the following textbook: H.B. Mitchell. Data Fusion: Concepts and Ideas. Springer (2012) and selected recent journal articles.
Assessment methods and criteria:
To pass the course, the student should return the exercises, complete a final programming project. Half of the grade will be based on exercises and half on the final project.
Grading:
The course will utilize a numerical grading scale 1-5. Zero stands for a fail.

Person responsible:
Jaakko Suutala and Markus Harju
Working life cooperation:
-
Other information:
Course uses Moodle platform.

521288S: Multiprocessor Programming, 5 op

Voimassaolo: 01.08.2015 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Computer Science and Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Praneeth Susarla

Opintokohteen kielet: Finnish

Leikkaavuudet:

521280S DSP Laboratory Work 5.0 op

ECTS Credits:
5 ECTS credits / 135 hours of work
Language of instruction:
English
Timing:
Spring semester, periods 3-4
Learning outcomes:
Upon completition 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:
Praneeth Susarla
Working life cooperation:
No.

521158S: Natural Language Processing and Text Mining, 5 op

Voimassaolo: 01.08.2017 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Computer Science and Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Mourad Oussalah

Opintokohteen kielet: English

ECTS Credits:
5 ECTS credits / 120 hours of works
Language of instruction:
English
Timing:
Period 1. It is recommended to complete the course at the end of period 1
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:
Introduction to Information Retrieval, by C. Manning, P. Raghavan, and H. Schütze. Cambridge University Press, 2008. (Free from http://nlp.stanford.edu/IR-book/) Foundations of statistical natural language processing, by Manning, Christopher D., Schütze, Hinrich. Cambridge, Mass.: MIT Press, 2000
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:
-

811606S: Next Generation Software Engineering, 5 op

Voimassaolo: 01.08.2019 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Information Processing Science DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Mika Mäntylä

Opintokohteen kielet: English

Leikkaavuudet:

811600S	Emerging Trends in Software Engineering	5.0 op

ECTS Credits:
5 ECTS credits / 133 hours of work
Language of instruction:
English
Timing:
The course is held in the spring semester, during period 4. It is recommended to complete the course at the 1st spring semester of the Master's studies.
Learning outcomes:
After passing the course, a student will be able to:
* descreibe the new trends in software engineering,
* perform computer supported trend mining to discover new trends of any given topic, as well as
* critically think and write about the trends.
Contents:
* Software engineering trends (varies)
* Automated trend mining from online databases
* Writing, arguing and discussing about the trends
Mode of delivery:
Face-to-face teaching
Learning activities and teaching methods:
Lectures 24 h, exercises 18 h, essays 30 h, project 30 h, independent study 31 h
Target group:
MSc students
Prerequisites and co-requisites:

The required prerequisite is that the learning outcomes of the following courses and their predecessors are accomplished: Software Engineering Research.
Recommended or required reading:
Articles, lectures, videos
Assessment methods and criteria:
Active lecture participation, exercises, assignments, essays
Grading:
Numerical scale 1-5 or fail
Person responsible:
Mika Mäntylä

031051S: Numerical Matrix Analysis, 5 op

Voimassaolo: 01.08.2012 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Applied Mathematics and Computational Mathematics

Arvostelu: 1 - 5, pass, fail

Opettajat: Marko Huhtanen

Opintokohteen kielet: 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:
Theory of matrix decompositions, SVD-decomposition, LU-decomposition, QR-decomposition, Schur-decomposition, FFT, eigenvalue- and generalized eigenvalue problems, matrix functions, GMRES, MINRES, Preconditioning.
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:
-

521108S: Optical Measurement Technology Exercise, 5 - 10 op

Opiskelumuoto: Advanced Studies
Laji: Course
Vastuuyksikkö: Electrical Engineering DP
Arvostelu: 1 - 5, pass, fail
Opettajat: Anssi Mäkynen
Opintokohteen kielet: Finnish

ECTS Credits:
5 – 10 ECTS credits / 140 - 280 hours of work.
Language of instruction:
Finnish or English.
Timing:
Periods 1 - 4.
Learning outcomes:
The student
1. is able to justify the chosen implementation principle.
2. is able to assess the suitability of the implementation method for different measurement needs.
3. is able to produce solutions for small-scale optical measurement engineering design tasks.
The detailed objectives of the course will vary depending on the assignment.

Contents:
The content and scope of the course will be confirmed on a case-by-case basis.
Mode of delivery:
Face-to-face teaching.
Learning activities and teaching methods:
Includes 140 to 280 hours of independently conducted work depending on the scope of exercise.
Target group:
All students of the University of Oulu can attend the course. Prime target is 4th year students in Electrical Engineering degree program.
Prerequisites and co-requisites:
-
Recommended optional programme components:
-
Recommended or required reading:
-

Assessment methods and criteria:
The course is carried out by completing the assignment.
Grading:
Numerical grading scale 1-5.
Person responsible:
Anssi Mäkynen
Working life cooperation:
No.
Other information:
-

521241A: Optical systems, 5 op

Voimassaolo: 01.08.2017 -
Opiskelumuoto: Intermediate Studies
Laji: Course
Vastuuyksikkö: Electrical Engineering DP
Arvostelu: 1 - 5, pass, fail

Opettajat: Anssi Mäkynen

Opintokohteen kielet: 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:
Cource 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
Working life cooperation:
-
Other information:
-

811607S: Persuasive Systems Design, 5 op

Voimassaolo: 01.08.2019 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Information Processing Science DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Oinas-Kukkonen, Harri Ilmari

Opintokohteen kielet: English

ECTS Credits:
5 ECTS credits / 133 hours of work
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's studies.
Learning outcomes:
After passing the course a student will be able to:
* analyze methods and techniques employed by persuasive systems,
* apply such methods in an ethical manner as design guidelines for developing persuasive ICT solutions, as well as
* apply gamification as persuasive design principles for serious games and other similar solutions.
Contents:
Attitudinal theories from social psychology have been quite extensively applied to the study of user intentions and behaviour. These theories have been developed mostly for predicting user acceptance of information technology rather than for providing systematic analysis and design methods for developing software solutions that aim at attitude or behaviour change. At the same time a growing number of information technology systems and services are being developed for these purposes.
This course will focus on persuasive technology. It will address the process of designing and evaluating persuasive systems, the types of content and software functionality in such systems, the underlying assumptions behind these, methods for analysing the persuasion context, and principles for persuasive system design. The course also looks into the methods and techniques of gamifying persuasive content.
The course is primarily geared towards analysis and design tasks using the Persuasive Systems Design model as the main approach. Gamification forms another segment of the course, introducing topics in the role of games and game-like experiences in supporting persuasion.
Mode of delivery:
Face-to-face teaching
Learning activities and teaching methods:
Lectures 20h, readings before lectures 21h, personal reflective exercises 21h, supervisory meetings 14h, project assignment 48h, other course related activity 10h.
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 optional programme components:
This course offers good groundwork for ICT and Behaviour Change course, but is not compulsory.
Recommended or required reading:
Research articles to be announced more specifcally during the course implementation
Assessment methods and criteria:
Participation in lectures, personal reflection reports, course assignments.
Grading:
Numerical scale 1-5 or fail
Person responsible:
Harri Oinas-Kukkonen

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

Voimassaolo: 01.08.2018 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Electrical Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Jukka Lahti

Opintokohteen kielet: 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 deign 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:

-

521015A: Practical Training, 3 op

Voimassaolo: 01.08.2005 -

Opiskelumuoto: Intermediate Studies

Laji: Practical training

Vastuuyksikkö: Electrical Engineering DP

Arvostelu: 1 - 5, pass, fail

Opintokohteen kielet: 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:
Jari Hannu

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 op

Voimassaolo: 01.01.2017 -

Opiskelumuoto: Intermediate Studies

Laji: Course

Vastuuyksikkö: Electrical Engineering DP

Arvostelu: 1 - 5, pass, fail

Opintokohteen kielet: 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 raport 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 assigments 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”.
Read more about assessment criteria at the University of Oulu webpage.
Person responsible:
Jari Hannu
Working life cooperation:
The course is carried out as practical trainingThe course is carried out as practical training.
Other information:
The BSc in electrical engineering degree can include optional practical training. This course is alternative to 521012A Practical Training, 3 ECTS.

521159P: Principles of Digital Fabrication, 5 op

Voimassaolo: 01.01.2017 -

Opiskelumuoto: Basic Studies

Laji: Course

Vastuuyksikkö: Computer Science and Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Georgi Georgiev

Opintokohteen kielet: Finnish

Leikkaavuudet:

ay521159P	Principles of Digital Fabrication (OPEN UNI)	5.0 op

ECTS Credits:
5 ECTS credits/ 135 hours of work
Language of instruction:
Finnish/English
Timing:
The course will be held in the spring semester, during period IV.

Learning outcomes:
In this course the students will learn the whole process of digital fabrication in FabLab. They will learn how to create an interactive 3D prototype, design mechanical parts for prototype, create basic electronics, implement a control logic for open hardware embedded board, and work in teams on project.
Contents:
The course teaches students to (1) design mechanical components with solid modeling tools, (2) build necessary electronics, and (3) implement software to a microcontroller, to create in FabLab a physical gadget that interacts with the world around it.
Mode of delivery:

Online (Lectures and TA sessions)/ Individual work towards project.
Learning activities and teaching methods:
Lectures 30h / Individual work 123h. There are sessions each week online where guidance is available (min total 16 h).
Target group:
This course is included in the computer science bachelor degree program. It is also available for all degree programs in the university. The course is offered to high-school 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:
There is no recommended or required reading. The tutorials for tools and software (or links to such tutorials) will be provided in the course.
Assessment methods and criteria:
The course will be evaluated on the basis of the project delivered by the teams of students. Essential part of this reporting is the documentation of the project.
Grading:
pass/fail
Person responsible:
Georgi Georgiev
Working life cooperation:
-
Other information:
The course is also offered to high-school students with special study right and gives 5 ECTS credits that can be included in some bachelor's degrees at University of Oulu.
Course work space can be found from University of Oulu Moodle platform moodle.oulu.fi

521229A: Principles of repurposing of electronics, 5 op

Voimassaolo: 01.08.2018 -

Opiskelumuoto: Intermediate Studies

Laji: Course

Vastuuyksikkö: Electrical Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Juha Häkkinen

Opintokohteen kielet: Finnish

ECTS Credits:
5 ECTS credits / 135 h student work
Language of instruction:
Finnish / English
Timing:
The course is held in the autumn semester, during periods I and II. Recommended time: BSc second year.
Learning outcomes:
Upon completion of the course, the student:
· is able to repurpose old electronics to create new applications and devices
· is able to create simple Arduino-based embedded programs
· is able to implement communication between two electrical devices/equipment
· is able to build own measurement instruments to enable hardware repurposing, such as a simple logic analyzer
· is able to create simple Android programs
· is able to deconstruct and take apart old electronics safely
· is able to recognize and repurpose old components removed from used electronics
· is able to safely solder and desolder electrical components
· is able to define and implement simple electrical systems and applications

Contents:
The course teaches students to use common methods to hack hardware in order to repurpose old electronic devices to new applications. These techniques include (a) patching into I/O, (b) replacing a component, (c) signal hacking using a logic analyzer, (d) firmware hacking using hex dump and (e) repurposing circuit boards and components removed from old

electronics. Major part of the course is dedicated to students own projects in groups to create devices and system using repurposed electronics such as old cell phones, PCs, printers etc.

Mode of delivery:
Contact teaching, project work in teams/pairs

Learning activities and teaching methods:
Lectures 12h, self study/project work 123h. Guidance for the self studi will be available weekly or at times agreed upon during the course.

Target group:
The course can be taken by students from any degree program, BSc or MSc level.

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. Any prior knowledge about Arduinoa and Android programming are beneficial. Principles of Digital Fabrication (521159P) is recommended,but not required

Recommended or required reading:
There is no recommended or required reading, since most of the basic ideas and examples can best be found from the internet. However, some of the key concepts can be found in Anderew Huang, ***The Hardware Hacker – Adventures in Making and Breaking Hardware***, March 2017, 416 pp., ISBN-13: 978-1-59327-758-1 and Joe Grand, Kevin Mitnick and Ryan Russell, ***Hardware Hacking - Have Fun while Voiding your Warranty***, 1st Edition, January 2004, 448 pp., eBook ISBN: 9780080478258, Paperback ISBN: 9781932266832

Assessment methods and criteria:
The course will be evaluated on the basis of the project delivered by the teams of students. Essential part of this reporting is the documentation of the project.
Read more about assessment criteria at the University of Oulu web page.

Grading:
The course is evaluated passed with honors/pass/fail

Person responsible:
Juha Häkkinen

Working life cooperation:
-

Other information:
-

521089S: Printed Electronics, 5 op

Voimassaolo: 01.08.2015 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Electrical Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Tapio Fabritius

Opintokohteen kielet: Finnish

Leikkaavuudet:

521217S	Printed Electronics	4.0 op
521095S	Advanced Course of Printed Electronics	3.0 op

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.

521175S: Printed electronics design and construction exercise, 5 op

Voimassaolo: 01.08.2019 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Electrical Engineering DP

Arvostelu: 1 - 5, pass, fail

Opintokohteen kielet: Finnish

ECTS Credits:
5 – 10 ECTS credits / 140 - 280 hours of work
Language of instruction:
English
Timing:
Period 3 - 5.
Learning outcomes:
During this course, students will learn about the practical aspects of various printing methods. In addition, students will gain hands-on experience on how to control the printing process according to their needs and application requirements. To increase the applicability of this course, students will be involved in the development of printed batteries.
This course consists of three cross-linked modules: theoretical, practical and analytical. After completing this course, students will be able to:
Theoretical
- Identify the main parameters governing the printing processes in various printing methods,
- Apply basic formulas and equations to predict ink-substrate interactions,
- Design basic models of printed batteries and their components by utilizing the most commonly used modeling software.

Practical
- Understand and apply basic principles governing the printing process,
- Create appropriate ink formulations and tune the printing process,
- Design and fabricate various thin-film structures by using screen and ink-jet printing methods.

Analytical
- Conduct characterization of inks and printed layers,

- Perform basic characterization of printed batteries,
- Present a concluding report of achieved results in a form understandable for a general audience.

Before starting this course, to increase the interaction, the students will be asked to provide one additional learning outcome based on their interests that will be appropriately formulated at the first session and included in the intended learning outcome.

Contents:
The content and scope of the course will be confirmed on a case-by-case basis. Primarily 5 ECTS cr.
Mode of delivery:
Independent work and face-to-face teaching
Learning activities and teaching methods:
Includes 140 to 280 hours of independently conducted work depending on the scope of exercise.
Target group:
All students of the University of Oulu can attend the course. Prime target 4th year students in Electrical Engineering degree program.
Prerequisites and co-requisites:
Printed electronics course 521089S (or equal) is needed to be admitted to this course.
Recommended optional programme components:
-
Recommended or required reading:
-
Assessment methods and criteria:
The course is carried out by completing the assignment.
Grading:
Numerical grading scale 1-5.
Person responsible:
Rafal Sliz
Working life cooperation:
No.

811373A: Professional Software Engineering Processes and Human Factors, 5 op

Voimassaolo: 01.08.2019 -

Opiskelumuoto: Intermediate Studies

Laji: Course

Vastuuyksikkö: Information Processing Science DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Minna Isomursu

Opintokohteen kielet: English

Leikkaavuudet:

ay811373A	Professional Software Engineering Processes and Human Factors (OPEN UNI	5.0 op
815662S	Software Engineering Management, Measurement and Improvement	5.0 op

ECTS Credits:
5 ECTS credits / 133 hours of work
Language of instruction:
English
Timing:
The course is held in the autumn semester, during period 2. It is recommended to complete the course in the 1st autumn semester of the Master's studies.
Learning outcomes:
After completing the student will be able to:
* recognize and describe software development processes models,
* evaluate and compare their applicability in different contexts,
* take human factors into account in planning and operating in professional software development,
* analyze their own strengths and improvement areas as software engineers to see opportunities for development, as well as
* participate in systematic efforts for improvement in software development organizations.

Contents:
Module 1: Software development process models. Theory and cases.
Module 2: Human factors in software development. Recognizing individual and team characteristics, and

cultivating personal awareness and developement pathways.
Module 3: Software process improvement. Theory and cases.
Mode of delivery:
Introduction lecture (not mandatory), online assignments, 2-3 lectures of visiting professionals (not mandatory), seminar (online option)
Learning activities and teaching methods:
Individual and group activities.
All materials, assignments and group work will be done online.
Target group:
MSc students
Prerequisites and co-requisites:
The required prerequisite is that the learning outcomes of the following courses and their predecessors are accomplished: Software Development, Maintenance and Operations.
Recommended or required reading:
Provided in Moodle.
Assessment methods and criteria:
Completing online assignments, active participation in peer feedback
Grading:
Pass or fail
Person responsible:
Minna Isomursu
Working life cooperation:
Visiting lectures of experienced software professionals (2-3)

521260S: Programmable Web Project, 5 op

Voimassaolo: 01.08.2006 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Computer Science and Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Ivan Sanchez Milara

Opintokohteen kielet: English

Leikkaavuudet:

ay521260S Programmable Web Project (OPEN UNI) 5.0 op

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 APIs, Hypermedia and HATEOAS, RESTful Clients
Mode of delivery:
Online learning.
Learning activities and teaching methods:

Lectures 4 h, guided laboratory exercise 15 h, the rest as self-study and group work. Each group implements software and writes a report. Students present their work at least twice in online meetings with the course staff.
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:
Mainly course slides and links to different Web resources announced during the first lecture. Course books: * Leonard Richardson, Mike Amundsen & Sam Ruby. RESTful Web APIs. O'Reilly Media 2013. ISBN: 978-1-4493-5806-8. * Leonard Richardson & Sam Ruby,RESTful Web Services. O'Reilly Media 2007. ISBN: 978-0-596-52926-0.
Assessment methods and criteria:
Course will be assessed based on project work assignment (functional working software prototype, content of the report…) and the exercises results. More detailed information on assessment will be provided with the course material.
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:
We will use Moodle to provide links to the working tools and information about distance learning: https://moodle.oulu.fi/course/view.php?id=6032

Course material can be found at Lovelace: https://lovelace.oulu.fi/.

811330A: Project management, 5 op

Opiskelumuoto: Intermediate Studies

Laji: Course

Vastuuyksikkö: Information Processing Science DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Kari Liukkunen

Opintokohteen kielet: Finnish

ECTS Credits:
5 ECTS credits / 133 hours of work
Language of instruction:
English, interaction with a project team may be in Finnish
Timing:
The course is held in the spring semester, during periods 3 - 4. Optional course. It is recommended to complete the course in the 1st spring semester of the Master's studies.
Learning outcomes:
After completing the course, the student will be able to:
* master the principles of a time management and priorisation needed in the project,
* gather information on the progress of a project and based on it, make project related decisions,
* apply theory on project management in practice,
* recognise risks of software projects and prepare for them,
* work as a project manager, as well as
* communicate with stakeholders by using both written and spoken language.
Contents:
Lectures give student tools to lead a software project focusingon leadership skills and common problem situations in project work.
Mode of delivery:
Blended teaching
Learning activities and teaching methods:

Lectures 10 h and indpendent work 123 h
Target group:
MSc students
Prerequisites and co-requisites:
The required prerequisite is that the student has completed BSc degree and has knowledge how to participate in a project as a team member.
Assessment methods and criteria:
Active participation in management training, succesfully leading project and drawing up the project plan and the learning diary.
Grading:
Numerical scale 1-5 or fail
Person responsible:
Kari Liukkunen
Working life cooperation:
Project topics are usually connected to companies

521225S: RF Components and Measurements, 5 op

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Electrical Engineering DP

Arvostelu: 1 - 5, pass, fail

Opintokohteen kielet: 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 d

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 execises 20 h, laboatory 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:
Handout, Lecture notes. A. Lehto, A. Räisänen: Mikroaaltomittaustekniikka (in Finnish), I. Bahl: Luped Elements for RF and Microwave circuits, R. Ludvig, P.Bretchko: RF circuit Desing: Theory ans Applications, Prentice Hall 2000 and literature announced at the beginning of the lectures.

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:
-

521386S: Radio Channels, 5 op

Voimassaolo: 01.08.2011 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Electrical Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Pekka Kyösti, Markus Berg

Opintokohteen kielet: 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:
The radio channels of different radio systems. Characterization of radio waves and propagation media. Different mechanisms of radio wave propagation: direct free-space propagation, absorption, scattering, reflection, refraction, diffraction, surface and ground waves, ionospheric waves and multipath propagation. Statistical description of fading radio channel. Principles of the radio channel modelling. Noise calculations. Radio wave propagation phenomena over fixed terrestrial, ionospheric and satellite links. Radio channel modelling for outdoor mobile systems. Radio wave propagation inside or into buildings. Radio channels of mobile satellite links. Slow fading. Multipath propagation and its effects on narrowband and wideband radio channels. MIMO radio channels. Measurement methods of radio channels. Atmospheric attenuation on terahertz frequency bands.
Mode of delivery:
Online teaching
Learning activities and teaching methods:
Lectures 28 h / Exercises 8 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:

Andreas Molisch. "Wireless Communications", 2012. Wireless Communications. Wiley-IEEE Press.
Simon R. Saunders & Alejandro Aragón-Zavala: Antennas and propagation for wireless communication systems. Second edition. John Wiley & Sons Ltd, 2007.

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:
-

521326S: Radio Engineering 1, 5 op

Voimassaolo: 01.08.2015 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Electrical Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Risto Vuohtoniemi, Aarno Pärssinen

Opintokohteen kielet: Finnish

Leikkaavuudet:

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

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 priciples 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:

The lectures and the exercises are organized as remote sessions.
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:
Lecture notes. Parts from D.M. Pozar: Microwave Engineering, 4th edition, John Wiley & Sons, Inc., 2012. Parts from B. Razavi: RF Microelectronics, 2nd edition, 2012. Also, additional material from other sources.
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:
-

521327S: Radio Engineering II, 6 op

Voimassaolo: 01.08.2015 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Electrical Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Risto Vuohtoniemi, Aarno Pärssinen

Opintokohteen kielet: English

Leikkaavuudet:

521375S	Design of Tranceivers	5.0 op
521375S-01	Exam, Radio Engineering II	0.0 op
521375S-02	Design of tranceivers, partial credit	0.0 op

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:
Remote 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:
Lecture notes. Parts from B. Razavi: Microelectronics, 2nd edition, 2012. Parts from A. Luzatto, M. Haridim: Wireless Transceiver Design, 2nd edition, 2017.

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:
-

813621S: Research Methods, 5 op

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Information Processing Science DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Netta Iivari

Opintokohteen kielet: English

Leikkaavuudet:

521146S Research Methods in Computer Science 5.0 op

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:
After completing the course, the student will able to:
* explain the general principles of scientific research and the practices of scientific methodology,
* generate research problems in information processing sciences,
* identify and describe the main research approaches and methods in information processing sciences, and choose the appropriate approach and method for a research problem,
* evaluate the methodological quality of a research publication, as well as
* 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:
Blended teaching
Learning activities and teaching methods:
Lectures / lecture videos 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

812354A: Servitisation, Co-Creation and Business Development, 5 op

Voimassaolo: 01.01.2021 -

Opiskelumuoto: Intermediate Studies

Laji: Course

Vastuuyksikkö: Information Processing Science DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Karin Väyrynen

Opintokohteen kielet: English

Leikkaavuudet:

ay812354A	Servitisation, Co-creation and Business Development (OPEN UNI)	5.0 op

ECTS Credits:
5 ECTS credits / 133 hours of work
Language of instruction:
English
Timing:
The course is held in the autumn semester, during period 2. It is recommended to complete the course in the 1st autumn semester of the Master's studies.
Learning outcomes:
After completing the course, the student will be able to:
* develop software business in new businesses and established businesses,
* conduct market analysis to estimate the market potential for the business,
* apply the basics of financial calculation,
* understand differences in business models,
* understand the concept of servitization, as well as
* understand the concept of co-creation.
Contents:
The course takes the perspectives of both new businesses and established businesses and their development. Students develop a new software business idea and write a business plan based on the idea. In addition, students are introduced to the concepts of servitization and co-creation, with special focus on already established businesses.
Mode of delivery:
Lecture videos, exercises
Learning activities and teaching methods:

Lecture videos and independent reading of material 35 hours, exercises 14 hours, individual and team assignments 60 hours, (home) exam 24 hours
Target group:
MSc students
Prerequisites and co-requisites:
The recommended prerequisite is that the learning outcomes of the following courses and their predecessors are accomplished: Digitalisation and Innovation
Recommended or required reading:
Provided in the digital learning space
Assessment methods and criteria:
The final grade is composed of the evaluations of the Business plan (teamwork), other individual/team assignments, and (home) exam.
Grading:
Numerical scale 1-5 or fail
Person responsible:
Karin Väyrynen
Other information:
The first lecture of the course is mandatory for all who want to participate in the course. It will be held on Monday, 26.10., from 14.15-16.00. You can join the lecture via Zoom here: https://oulu.zoom.us/j/67895947285. Please be on time.

Exercises are mandatory (via Zoom, link will be available in Moodle). Make sure you are enrolled to an exercise group, not only to the lectures.

IMPORTANT: Due to the University's requirement to offer the course as distant teaching only, only exercise group 1 (Tuesdays at 8.15-10.00) will be held.
All other lectures except lecture 1, and all lecture material and course information will be available in the Moodle environment of the course.
The Moodle workspace will be available starting from 24.10. here: https://moodle.oulu.fi/course/view.php?id=5204.

The first assignments have to be completed already BEFORE the first exercise (which is held on 3.11.), so make sure you attend the first lecture and complete the first assignments on time.

In the course, there are some assignments that have to be done on a specific day (no change in schedules possible!), so please reserve already now time in your calendars on the following days:
Monday, 16.11.: reserve 2 hours for a course assignment
Monday, 7.12.: reserve 4 hours for a course assignment

Other assignment deadlines will be available in the Moodle workspace upon the start of the course.

521279S: Signal Processing Systems, 5 op

Voimassaolo: 01.08.2012 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Computer Science and Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Pekka Sangi

Opintokohteen kielet: Finnish

ECTS Credits:
5 ECTS credits / 135 hours of work
Language of instruction:
English
Timing:
The course is held in the autumn semester, during period II. For master students of Computer Science and Engineering specializing in Computer Engineering, it is recommended to complete the course at the first autumn semester.
Learning outcomes:
Learning outcomes of the course are:

1. The student understands common real number formats used in digital signal processing.

2. The student can implement a digital filter using fixed-point computations. He can optimize word lengths so that the required performance goals are fulfilled.
3. The student knows the CORDIC algorithm and can utilize it in the implementation of function and transform (e.g. DCT) computations.
4. The student knows the principles, which allow computationally efficient implementation of decimation and interpolation operations. Related to this, he can implement narrow-band digital filters.
5. The student can explain how a modulated filter bank works and knows its polyphase decomposition based implementation.
6. The student can implement convolution for long data sequences and filters. He also knows, how the same principles are used in the implementation of correlation.
7. The student can explain the general operational principles of adaptive filters and knows some of their applications. He knows operation of some common adaptive algorithms. He can study behaviour of adaptive filters with simulation.

Some exercise tasks of the course are done in the Matlab environment utilizing also its Simulink tool. The student learns how it can be used in the modelling of signal processing systems.

Contents:
Fixed-point and floating-point arithmetics, fixed-point filter implementation, CORDIC, DCT, FFT, polyphase decomposition, multirate signal processing, modulated filter banks, sectioning, adaptive filters and algorithms, Matlab and Simulink tools in DSP modelling.
Mode of delivery:
The tuition will be implemented as face-to-face teaching and web-based teaching. Moodle is used as the learning environment.
Due to Covid-19 pandemic, teaching in Autumn 2020 will be implemented remotely. Details of arrangement can be found from the course web page, which will be available from October 16 in Moodle.
Learning activities and teaching methods:
Lectures 28 h / Group work 42 h / Self-study 65 h. The group work consists of six weekly design tasks.
Target group:
The course is primarily targeted to the students of Computer Science and Engineering specializing to Computer Engineering.
Prerequisites and co-requisites:
A recommended prerequisite is the completion of "521337A Digital Filters".
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 provides lecture notes for reading. In addition, the following books provide useful information:
E.C. Ifeachor, B.W. Jervis. Digital Signal Processing - A Practical Approach. Second Edition. Prentice-Hall, 2002.
W.T. Padgett, D.V. Anderson. Fixed-Point Signal Processing. Morgan&Claypool Publishers, 2009.
Assessment methods and criteria:
The course uses continuous assessment, which is based on evaluation of the weekly group works and exams arranged during lectures.
Grading:
The course utilizes a numerical grading scale 0-5. In the numerical scale zero stands for a fail.
Person responsible:
Pekka Sangi
Working life cooperation:
The course does not contain working life cooperation. There may be guest lectures.
Other information:

The web page of the course arranged at Autumn 2020 will be https://moodle.oulu.fi/course/view.php?id=3212

521328A: Simulations and Tools for Telecommunications, 5 op

Voimassaolo: 01.08.2015 -

Opiskelumuoto: Intermediate Studies

Laji: Course

Vastuuyksikkö: Electrical Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Johanna Vartiainen

Opintokohteen kielet: Finnish

Leikkaavuudet:

521369A Simulations and Tools for Telecommunications 3.0 op
521369A-01 Simulations and Tools for Telecommunications, exam 0.0 op
521369A-02 Simulations and Tools for Telecomm. exercise 0.0 op

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:
Lecture notes. Selected parts (informed in the notes) of Michel C. Jeruchim, Philip Balaban, and K. Sam Shanmugan, Simulation of Communication Systems, Modeling Methodology and Techniques, 2nd edition. Plenum Press, 2000. Additional reading: William H. Tranter, K. Sam Shanmugan, Theodore S. Rappaport, Kurt L. Kosbar, Principles of Communication Systems Simulation with Wireless Applications, Prentice Hall, 2004.
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:
In 2020, the whole course including compulsory exercise and exam is organized in Moodle https://moodle.oulu.fi/enrol/index.php?id=3757 (opens no later than one week before the start of the course)

521044A: Social Computing, 5 op

Voimassaolo: 01.08.2018 -

Opiskelumuoto: Intermediate Studies

Laji: Course

Vastuuyksikkö: Computer Science and Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Simo Hosio

Opintokohteen kielet: English

ECTS Credits:
5 ECTS cr / 135 hours of work
Language of instruction:
English.
Timing:
Autumn semseter, period I.
Learning outcomes:
By the end of the course, students:

- possess the skills for analysing (reverse-engineering) social applications that consist of individuals and computing devices in a variety of contexts.
- can design social software, especially software that deal with crowdsourcing and human-computation
- have advanced understanding of both the positive and negative real-world consequences/aspects of social aspects of computing online
- are able to explain human behaviour with social computing systems by using selected basic theories from such as sociology or psychology

Contents:
Basics of social computing, computer-mediated human communication, designing social software, analysing social computing projects, crowdsourcing
Mode of delivery:
The course consists of lectures, exercises and individual / group-based assignments.
Learning activities and teaching methods:
The course consists of lectures (12h), exercises (16h), assignments and self-study (102h).
Target group:
M.Sc. and B.Sc. students. The course recommended for anyone who wishes to strengthen their expertise on social aspects of computational systems as well as designing for humans.
Prerequisites and co-requisites:
No recommended or required preparations.
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 design exercises that demand some experience with computer programs (not programming per se).
Recommended or required reading:
Required reading will be delivered during the course.
Assessment methods and criteria:
The course completion relies on a number of completed solo-works (such as reflections and evaluation of specific online systems that are graded). The majority of the numerical assessment is project-based. Students have to complete several individual exercises throughout the semester: ideating an application, designing various versions of its prototype, evaluating those prototypes, documenting the final application designs. Passing criteria: all stages of the project-based work must be completed, each receiving more than 50% of the available points.
Grading:
The course unit utilizes a numerical grading scale 1-5. In the numerical scale zero stands for a fail.
Person responsible:
Associate Professor Simo Hosio
Assistant Ville Paananen
Working life cooperation:
The course contains optional guest lectures.
Other information:
Uses Moodle as the learning environment: https://moodle.oulu.fi/course/view.php?id=4449

811372A: Software Development, Maintenance and Operations, 5 op

Voimassaolo: 01.08.2019 -

Opiskelumuoto: Intermediate Studies

Laji: Course

Vastuuyksikkö: Information Processing Science DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Mika Mäntylä

Opintokohteen kielet: English

Leikkaavuudet:

ay811372A Software Development, Maintenance and Operations (OPEN UNI) 5.0 op

815312A Software Production and Maintenance 5.0 op

ECTS Credits:
5 ECTS credits / 133 hours of work
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 autumn semester of the Master's studies.
Learning outcomes:
After completing the course, the student will able to:
* explain and utilize theories of software evolution,
* utilize the processes, techniques and tools for software deployment, and operations,
* utilize the processes, techniques and tools for software maintenance, as well as
* utilize the processes, techniques and tools to better understand and maintain large code bases.
Contents:
* Software Maintenance and Evolution
* Software Product Lines
* Software Maintenance and Evolution Models
* DevOps
* Reengineering
* Legacy Systems
Mode of delivery:
Blended teaching
Learning activities and teaching methods:
Lectures (Video): 20 h, exercises / assignments 78 h, weekly study 42 h
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 programming.
Recommended or required reading:
Videos, books, exercises
Assessment methods and criteria:
Exercises, assignements
Grading:
Numerical scale 1-5 or fail
Person responsible:
Mika Mäntylä

815663S: Software Engineering Research, 5 op

Voimassaolo: 01.08.2015 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Information Processing Science DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Oivo, Markku Tapani

Opintokohteen kielet: English

ECTS Credits:
5 ECTS credits / 133 hours of work.
Language of instruction:
English
Timing:
The course is held in the spring semester, during period 3. It is recommended to complete the course in the 1st spring semester of the Master's studies.
Learning outcomes:
After completing the course, the student will able to:
* describe the current research areas in software engineering and the most important software engineering research methods,
* describe academic research and publishing in software engineering,
* critically analyse scientific articles from the viewpoint of the content and research methods used in the article,
* present academic research, as well as
* actively participate in an academic discussion of research papers and research results.
Contents:
State of the art research methods and topics in software engineering.
Mode of delivery:
Face-to-face teaching.
Learning activities and teaching methods:
Lectures and seminars 28 h, exercises / assignments 78 h, weekly study 42 h.
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 or Information Systems.
Recommended or required reading:

Assessment methods and criteria:
Active participation in lectures and attendance. Final grade is composed of attendance, assignments and term paper. No remote participation or distance learning.
Grading:
Numerical scale 1-5 or fail.
Person responsible:
Markku Oivo

811603S: Software Platforms and Ecosystems, 5 op

Voimassaolo: 01.08.2019 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Information Processing Science DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Juustila, Antti Juhani

Opintokohteen kielet: English

ECTS Credits:
5 ECTS credits / 133 hours of work
Language of instruction:
English
Timing:
The course is held in the autumn semester, during period 2. It is recommended to complete the course in the 2nd autumn semester of the Master's studies.
Learning outcomes:
After completing the course, the student will be able to:
* define what are software platforms and ecosystems,
* understand how software platforms and ecosystems can be used for business,
* analyze the benefits and drawbacks of different platforms or ecosystems, as well as
* operate, use and make contributions to a particular software platform or ecosystem.
Contents:

* Introduction to software platforms and ecosystems
* Business and strategic aspects of platforms and ecosystems
* Development of software systems utilizing platforms or ecosystems
* Benefits and drawbacks of platforms or ecosystems - business and development views
* Case studies, practical project with a selected platform or ecosystem

Mode of delivery:
Lectures, exercises, group work, demonstrations, project work.
Learning activities and teaching methods:
Lectures 24 h, exercises or group work 24 h, independent study 52 h, assignments 48 h
Target group:
MSc students
Prerequisites and co-requisites:
The required prerequisite is that the learning outcomes of the following courses and their predecessors are accomplished: Advances Software Quality and Security
Recommended or required reading:
Announced in the beginning of the course
Assessment methods and criteria:
Exam, graded project work and reports, graded assignments.
Grading:
Numerical scale 1-5 or fail.
Person responsible:
Antti Juustila

521479S: Software Project, 7 op

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Computer Science and Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Christian Wieser

Opintokohteen kielet: 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:

521457A Software Engineering, 521453A Operating Systems, 521141P Elementary Programming, 521286A Computer Systems or 521142A Embedded Systems Programming and varying project related background reading.
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:
Pressman, R.S.: Software Engineering A Practitioner's Approach, 4th edition, Mc Graw-Hill, 1997; Phillips, D.: The Software Project Manager's Handbook, IEEE Computer Society, 2000; Project documentation; project related manuals and handbooks.
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:
-

811604S: Software for Intelligent Systems and Artificial Intelligence (AI), 5 op

Voimassaolo: 01.08.2019 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Information Processing Science DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Minna Isomursu

Opintokohteen kielet: English

ECTS Credits:
5 ECTS credits / 133 hours of work
Language of instruction:
English
Timing:
The course is held in the spring semester, during period 3. It is recommended to complete the course in the 2nd spring semester of the Master's studies.
Learning outcomes:
After completing the course, the students will be able to:
* reflect and critically assess the role of AI in software intensive services,
* reflect and discuss issues related to design of software intensive services using AI, as well as
* develop a project using the methods and theory learned throughout the course.
Contents:
The course consists of four main modules. These are:
* Introduction to the course
* Basics of AI in software intensive services
* AI project, the theme will be decided yearly
* theoretical reflective learnings
Mode of delivery:
Introduction lecture, online assignments, final seminar
Learning activities and teaching methods:
Individual online assignments, project work executed in groups, peer feedback in seminar
Target group:
MSc students
Prerequisites and co-requisites:
The required prerequisite is that the learning outcomes of the following courses and their predecessors are accomplished: Software Platforms and Ecosystems
Recommended or required reading:
Provided in Moodle
Assessment methods and criteria:

Online assignments, project work with presentation
Grading:
Pass or fail
Person responsible:
Minna Isomursu

811605S: Software-Defined Products, Systems and Services, 5 op

Voimassaolo: 01.08.2019 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Information Processing Science DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Tero Päivärinta

Opintokohteen kielet: English

ECTS Credits:
5 ECTS credits / 133 hours of work
Language of instruction:
English
Timing:
The course is held in the spring semester, during period 4. It is recommended to complete the course in the 2nd spring semester of the Master's studies.
Learning outcomes:
After completing the course, the student is able to:
* describe the contemporary main concepts of the "software-defined everything" (SDx) perspective, such as software-defined networks, software-defined storage, software-defined data centers, software-defined computing,
* identify relevant software platforms and tools for developing solutions under the software-defined perspective (cf. the previous main concepts),
* present a service, system or product concept of her/his own interest transformed by the software-defined perspective, as well as
* develop and present a small-scale software project in a group to demonstrate a relevant aspect of the software-defined perspective.
Contents:
*Introduction to the main contemporary concepts of SDx ("Software-defined everything")
* Exemplary "software-defined" concepts to re-think products, systems, services
* Examples of typical software tools for implementing some of the related concepts
* Practical project on a selected software-defined concept (presentation and demonstrative implementation) with a selected development environment
Mode of delivery:
Lectures, seminar on student-defined concepts, project work, seminar on project presentations
Learning activities and teaching methods:
Lectures 12 h (on concepts; potentially guest lectures), Seminars 16 h (of student attendance), Independent study on the selected concept 24 h, project work 90 h
Target group:
MSc students
Prerequisites and co-requisites:
The required prerequisite is that the learning outcomes of the following courses and their predecessors are accomplished: Software Platforms and Ecosystems
Recommended or required reading:
Announced in the beginning of the course (timely articles and other materials)
Assessment methods and criteria:
Individual assignment, project work with presentation. (Depending on the number of students attending, the assignment on the conceptual idea for a new software-defined product, system or service can also be conducted as a part of the group assignment, according to the choice of the teacher.)
Grading:
Numerical scale 1-5 or fail
Person responsible:
Tero Päivärinta
Working life cooperation:
Possibly visiting lectures from companies or other organizations.

Other information:
The research groups related to the software-defined timpely projects and solutions can be invited to suggest relevant small-scale project topics for the students.

521149S: Special Course in Information Technology, 5 - 8 op

Voimassaolo: 01.08.2012 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Computer Science and Engineering DP

Arvostelu: 1 - 5, pass, fail

Opintokohteen kielet: English

Voidaan suorittaa useasti: Kyllä

ECTS Credits:
5-8
Language of instruction:
English
Timing:
Autumn and Spring, periods 1-4.
Learning outcomes:
The learning outcomes are defined based on the course topic.
Contents:
Varies yearly.
Mode of delivery:
Face-to-face teaching, also web-based teaching can be used.
Learning activities and teaching methods:
Lectures, exercises, design exercise, project work and seminars depending on the topic of the year. The 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:
M.Sc. level students of Computer Science and Engineering; other students are accepted if there is space in the classes.
Prerequisites and co-requisites:
Will be defined based on the contents.
Recommended optional programme components:
No.
Recommended or required reading:
Will be announced at the first lecture
Assessment methods and criteria:
Depends on the working methods.
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:
Professor of CSE
Working life cooperation:
-
Other information:
Course work space can be found from University of Oulu Moodle platform moodle.oulu.fi.

521393S: Statistical Communication Theory, 7 op

Voimassaolo: 01.08.2019 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Electrical Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Rajatheva Rajatheva

Opintokohteen kielet: English

ECTS Credits:
7
Language of instruction:
English
Timing:
Fall, period 1-2, every other year, 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
Detection, Estimation, and Modulation Theory, Part I, 2nd Edition by Harry L. Van Trees, Kristine L. Bell, and Zhi Tian, Wiley, 2013.
Principles of Mobile Communications, G. Stuber, Springer, 2012. Wireless Communications,
A. Molisch, John Wiley & Sons, 2nd Edition, 2011. Lecture notes and other literature.
Principles of Communication Engineering,John M. Wozencraft, Irwin Mark Jacobs, McGraw Hill.
Lecture notes and other literature.
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.

521348S: Statistical Signal Processing 1, 5 op

Voimassaolo: 01.08.2016 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Electrical Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Janne Lehtomäki, Juntti, Markku Johannes

Opintokohteen kielet: Finnish

Leikkaavuudet:

521484A Statistical Signal Processing 5.0 op

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 quadratic optimization and can apply them in solving signal processing problems.
2. understands how to handle complex valued random variables and processes.
3. understands the key concepts in estimation theory such as the classical and Bayesian philosophies.
4. masters the most important estimation principles such as minimum variance, maximum likelihood, least squares and minimum mean square error estimators.
5. can derive an estimator for a given criterion and basic data models.
6. can use the methodology of estimation theory to analyze the performance of estimators and compare to performance benchmarks such as the Cramer-Rao lower bound.
7. understands the basics of detection and classification theory: hypothesis testing, receiver operating characteristics (ROC), the Neyman-Pearson and Bayesian detectors.

Contents:
Review of probability, complex valued random variables and stochastic processes; linear algebra, eigenvalue decomposition, SVD (Singular value decomposition), use of Matlab; 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; statistical decision theory, receiver operating characteristics, hypothesis testing, matched filter.
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. The recommended prerequisite is the completion of 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:
1. Steven M Kay, "Fundamentals of statistical signal processing: estimation theory."vol 1 Prentice Hall 1993.
2. Steven M. Kay, "Fundamentals of statistical signal processing: Detection theory, vol. 2." Prentice Hall 1999.
3. Peter Selinger, “Matrix Theory and Linear Algebra”, Creative Commons.
4. Paolo Prandoni & Martin Vetterli, Martin, “Signal Processing for Communications”, CRC Press 2008.
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:

Lecture materials etc. can be found on Moodle https://moodle.oulu.fi/course/view.php?id=4203.

521324S: Statistical Signal Processing II, 5 op

Voimassaolo: 01.08.2015 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Electrical Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Juntti, Markku Johannes

Opintokohteen kielet: English

Leikkaavuudet:

521373S	Statistical Signal Processing 2	6.0 op
521373S-01	Statistical Signal Processing 2, exam	0.0 op
521373S-02	Exercise work, Communication Signal Processing I	0.0 op

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 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 signal processing applications.
3. can use linear algebra, basics of optimization and statistical signal processing to derive algorithms with statistical models.
4. can use numerical analysis to approximate optimal algorithms with iterative solutions including 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.
7. can solve simple composite hypothesis testing problems with unknown parameters

Contents:

Linear Bayesian estimators and filters, sequential Bayesian and least squares algorithms, Wiener and Kalman filtering, iterative algorithms, adaptive filtering and algorithms, statistical decision theory for signals with unknown parameters, application examples: equalization in communications engineering, array processing and beamforming, spectral analysis and estimation, delay estimation and positioning.

Mode of delivery:

Online teching and e-learning tool usage

Learning activities and teaching methods:

Online 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, 521348S Statistical Signal Processing I. The recommended prerequisite is the completion of 521330A Telecommunications Engineering, 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:
1. Steven M Kay, "Fundamentals of statistical signal processing: estimation theory," vol. 1. Prentice Hall 1993.
2. Steven M. Kay, "Fundamentals of statistical signal processing: Detection theory," vol. 2. Prentice Hall 1998.
3. Simon Haykin, "Adaptive Filter Theory", 3rd ed. or newer, Prentice Hall 1996.
4. Gene H. Golub & Charlers F. Van Loan, "Matrix computations", 3rd ed. or newer, Johns Hopkins University Press 1996.
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 0.6 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
Working life cooperation:
No
Other information:
Lecture materials etc. can be found on Moodle: https://moodle.oulu.fi/course/view.php?id=6010

521322S: Telecommunication Engineering Project, 5 op

Voimassaolo: 01.08.2015 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Electrical Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Markus Berg, Saarnisaari, Harri Tapani

Opintokohteen kielet: Finnish

Leikkaavuudet:

521387S	Telecommunication Engineering Project	4.0 op

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:
-

521402S: Telecommunications Circuit Design, 6 op

Voimassaolo: 01.08.2017 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Electrical Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Rahkonen, Timo Erkki

Opintokohteen kielet: 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 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 excercise 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.

521098S: Testing Techniques of Electronics and Printed Electronics, 5 op

Voimassaolo: 01.08.2015 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Electrical Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Tapio Fabritius

Opintokohteen kielet: 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.

521156S: Towards Data Mining, 5 op

Voimassaolo: 01.08.2017 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Computer Science and Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Satu Tamminen

Opintokohteen kielet: Finnish

ECTS Credits:
5 ECTS credits
Language of instruction:
English
Timing:
Autumn, period I.
Learning outcomes:
After completing this course, student can recognize data types and perform required pre-processing steps before further analysis:

1. Student can design and implement a data collection process
2. Student can combine data from different sources
3. Student can normalize and transform data, and handle missing or incorrect values
4. Student can ensure 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:
Moodle: https://moodle.oulu.fi/course/view.php?id=1679
Towards Data Mining 521156S:3

521154S: UBISS - International UBI Summer School, 5 op

Voimassaolo: 01.08.2015 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Computer Science and Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Ojala, Timo Kullervo

Opintokohteen kielet: English

Voidaan suorittaa useasti: Kyllä

ECTS Credits:
5 ECTS credits / 133 hours of work
Language of instruction:
English.
Timing:
Summer semester (June).
Learning outcomes:
Summer school comprises of multiple parallel workshops that each have specific learning outcomes.
Contents:
Each workshop has specific contents.
Mode of delivery:
Face-to-face teaching in workshops.
Learning activities and teaching methods:
Lectures, a project completed as group work, self-study.
Target group:
MSc. and doctoral students.
Prerequisites and co-requisites:
Each workshop may have specific prerequisites.
Recommended optional programme components:
None.
Recommended or required reading:
Each workshop has a specific required reading package.
Assessment methods and criteria:
Final exam (50%), project (50%).
Grading:
The summer school uses a numerical grading scale 1-5.
Person responsible:
Professor Timo Ojala.
Working life cooperation:
None
Other information:
Course work space can be found from University of Oulu Moodle platform moodle.oulu.fi.

812355A: User Experience (UX) Design and Management, 5 op

Voimassaolo: 01.08.2020 -

Opiskelumuoto: Intermediate Studies

Laji: Course

Vastuuyksikkö: Information Processing Science DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Leena Arhippainen

Opintokohteen kielet: English

ECTS Credits:
5 ECTS credits / 133 hours of work
Language of instruction:
English
Timing:
The course is held in the autumn semester, during period 1. It is recommended to complete the course in the 2nd autumn semester of the Master's studies. The course is not implemented in Academic year 2020-2021.
Learning outcomes:
After completing the course, the student will be able to:
* describe the significance and is able conceptualize user experience and human interaction with digital products, systems, and services,
* describe the central concepts, factors shaping and potential problems associated with user experience and human interaction with digital products, systems, and services,
* describe various interaction design, user experience design, service design and design thinking methods and use some of them in a practical design case of a novel digital product, system or service as well as
* describe various kinds of management, organizational, social, cultural and political aspects and challenges of user experience design.
Contents:
Central concepts (user experience, interaction design, design thinking, service design), human interaction with digital products, systems, and services, various user experience design, interaction design, service design and design thinking methods, management, organizational, social, cultural and political aspects and challenges of user experience design.
Mode of delivery:
Face-to-face teaching.
Learning activities and teaching methods:
Lectures, exercises, groupwork, individual assignments, seminar
Target group:
MSc students
Prerequisites and co-requisites:
The recommended prerequisite is that the learning outcomes of the following courses and their predecessors are accomplished: Servitisation, Co-Creation and Business Development.
Recommended or required reading:
Scientific articles and books
Assessment methods and criteria:
During the course, the students will be carrying out a groupwork assignments and individual tasks. These will be assessed based on the learning outcomes of the course. The assessment criteria and the requirements will be explained in detail during the opening lecture of the course.
Grading:
Numerical scale 1-5 or fail
Person responsible:
Netta Iivari
Working life cooperation:
Guest lectures, customer assignments

812671S: User Experience (UX) and Usability Evaluation, 5 op

Voimassaolo: 01.08.2011 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Information Processing Science DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Dorina Rajanen

Opintokohteen kielet: English

ECTS Credits:
5 ECTS credits / 133 hours of work.
Language of instruction:
English

Timing:
The course is held in the spring semester, during period 4. It is recommended to complete the course in the 1st spring semester of the Master's studies.
Learning outcomes:
After completing the course, the student will be able to:
* design and follow through a UX/usability evaluation process,
* design test scenarios and tasks,
* select participants,
* plan and follow through the evaluation in laboratory or in the field, as well as
* analyse and report the findings from the evaluations.
Contents:
Basic terms and types of UX and usability testing, usability and UX tests process, usability and UX test tasks and scenarios, test subjects, following through a usability and UX tests, analysing usability and UX test material, reporting the findings from usability and UX tests.
Mode of delivery:
Face-to-face teaching
Learning activities and teaching methods:
Lectures 24h, assignment tutoring 13h, assignment 90h, seminar 7h.
Target group:
MSc students

Prerequisites and co-requisites:
The recommended prerequisite is that the learning outcomes of the following courses and their predecessors are accomplished: Servitisation, Co-Creation and Business Development.
Recommended optional programme components:

Recommended or required reading:
Dumas, J. S. & Redish, J. C. (1993): A Practical Guide to Usability Testing. Ablex Publishing Corporation. Rubin, J. (1994): Handbook of Usability Testing: How to Plan, Design, and Conduct Effective Tests. Chichester: John Wiley & Sons, Inc.
Assessment methods and criteria:

Assessment of the course is based on the learning outcomes of the course based on the written usability test plan, supervised usability tests, written usability test report and oral seminar presentation
Grading:
Pass or fail
Person responsible:
Mikko Rajanen
Working life cooperation:
Students learn how to collaborate with real customers
Other information:

521291S: VR Systems and Humans, 5 op

Voimassaolo: 01.08.2020 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Computer Science and Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Paula Alavesa

Opintokohteen kielet: English

ECTS Credits:
5 ECTS / 135 hours of work.
Language of instruction:
Primary instruction language is English.
Timing:
The course is held in the autumn semester, during period II. It is recommended to complete the course at the 4rd autumn semester.

Learning outcomes:
Upon completion of the course, the student will:

- Gain knowledge in human physiology and human perception in relationship to VR.
- Understand common perceptual flaws of modern VR systems related to resolution, latency, frame rates, tracking, lens aberrations, drift, and jitter.
- Be able to critically assess a given VR system or experience, and recommend improvements.
- Formulate a hypothesis about a VR experience, create such a VR experience in Unity3D, and design a human subject experiment testing the hypothesis.

Contents:
Overview of human physiology, neuroscience, and human perception with relationship to VR. Depth and scale perception. Perception of screen resolution, perception of motion. Perceptually optimal parameters for frame rate, latency, and drift in VR systems. Perceptual training. Comfort and VR sickness. Psychophysical experiments. Design of human subjects experiments.
Mode of delivery:
The lectures will be held online in Zoom https://oulu.zoom.us/j/64488083079
The courseMoodle site is at https://moodle.oulu.fi/enrol/index.php?id=3356

For exercise we will have three groups of 12 people that can attend at TS135. If the students do not have their own face masks, those will be provided. The students are expected to finish the exercise that require using VR headsets in two weeks. The students are also allowed to use their own VR headsets at home, and there are few headsets that can be borrowed for two weeks at a time. The exercise groups are held 4.11.-13.11., 18.11.-27.11. and 2.12.-11.12. During the first week of the course the students are expected to signup for one of these exercise groups, or independent work. There will be no exercise session during the first week of the course.
Learning activities and teaching methods:
The course will utilize the VR-ready computer room for both teaching and exercises. The course will consist of lectures (28h), individual lab exercises (28h), team project (28h), self-study (48h), and the final exam (3h). Parts of the exercise lab work will be organized as guided teaching.
Target group:
B.Sc. and M.Sc. students in all areas, especially applied computing and human sciences.
Prerequisites and co-requisites:
It is required that the students complete 521293A, Introduction to XR Systems, prior to enrolling for the course. It is recommended, but not required, that the students also take 521040A, 3D environments and Applications, prior to enrolling for the current course.
Recommended optional programme components:
The course is an independent entity, and does not require other additional studies carried out at the same time.
Recommended or required reading:
Online-material that is delivered throughout the course.
Assessment methods and criteria:
The students are assessed according to their performance in assignments, in-lecture quizzes, final project, and the final exam. The assessment criteria are based on the learning goals of the course.
Grading:
Numerical (0-5). In the numerical scale zero stands for a fail.
Person responsible:
Paula Alavesa
Working life cooperation:
When possible, a guest lecture will be held by a visitor from a VR company.

521395S: Wireless Communications I, 5 op

Voimassaolo: 01.08.2019 -

Opiskelumuoto: Advanced Studies

Laji: Course

Vastuuyksikkö: Electrical Engineering DP

Arvostelu: 1 - 5, pass, fail

Opettajat: Timo Kokkonen, Jari Iinatti

Opintokohteen kielet: English

Leikkaavuudet:

521395S-01 Wireless Communications I, Exam 0.0 op
521395S-02 Wireless Communications I, Exercise 0.0 op
521323S Wireless Communications 2 5.0 op
521323S-02 Wireless Communications I, Exercise 0.0 op
521320S Wireless Communications 2 8.0 op
521320S-01 Intermediate exam or final exam, Wireless Communications 2 0.0 op
521320S-02 Exercise work, Wireless Communications 1 0.0 op
521323S-01 Wireless Communications I, Exam 0.0 op

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.
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:
Andrea Goldsmith: Wireless Communications, Cambridge University Press, 2005.
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:
Visiting lecturers from industry.
Other information:
-

521349S: Wireless Communications II, 5 op

Opiskelumuoto: Advanced Studies
Laji: Course
Vastuuyksikkö: Electrical Engineering DP

Arvostelu: 1 - 5, pass, fail
Opettajat: Antti-Heikki Tölli
Opintokohteen kielet: English

ECTS Credits:
5
Language of instruction:
English
Timing:
Spring, period 3
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:
Fully remotely,
https://moodle.oulu.fi/course/view.php?id=2086
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.
Andrea Goldsmith: Wireless Communications, Cambridge University Press, 2005, Chapters 4, 9-11.
14. Upamanyu Madhow: Fundamentals of Digital Communication, Cambridge University Press, 2008, Chapter 5 (Equalization).
Supporting material: Cover & Thomas, "Elements of Information Theory", John Wiley & Sons; Boyd & Vandenberghe, "Convex Optimization", Cambridge University Press, 2004.
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).

521097S: Wireless Measurements, 5 op

Voimassaolo: 01.08.2015 -
Opiskelumuoto: Advanced Studies
Laji: Course
Vastuuyksikkö: Electrical Engineering DP
Arvostelu: 1 - 5, pass, fail
Opettajat: Christian Schuss
Opintokohteen kielet: English
Leikkaavuudet:

521114S	Wireless Measurements	4.0 op
521114S-01	Wireless Measurements, exam	0.0 op
521114S-02	Wireless Measurements, exercise work	0.0 op

ECTS Credits:
5 ECTS credits / 128h
Language of instruction:
In English
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 prerequirements, 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:
Christian Schuss
Working life cooperation:
No.