Curriculum 2016-2017
School: SCI
Department: Department of Computer Science (T3130)
Level: Master's level
Languages: finnish, swedish, english

CS-C3180 Software Design and Modelling (5 cr)

Responsible teacher: Varvana Myllärniemi; Marjo Kauppinen
Status of the Course: Common course of the Software and Service Engineering major (Master's level).
Level of the Course: Master's level
Teaching period: I-II (Autumn)
Workload: Study sessions (lectures): 30h, Workshops and individual work: 40h, Group assignments: 60h
Learning Outcomes: This course aims to help you learn how to analyze the problem the customer has and how to design a solution that satisfies customer and user needs. You learn to describe the essence of the key software engineering activities and how these activities relate to each other. You are also able to compare modeling methods, assess their applicability for different software engineering activities and select appropriate design practices for the development team. Furthermore, you are able to apply a set of design and modeling methods in practice.
Content: After the course, the student will have a broad understanding of software engineering activities and methods as a whole and have basic skills to participate in software development projects. The software engineering activities covered in this course are: a) requirements engineering, b) domain modeling, c) software architecture design, d) testing, and e) teamwork.
Assessment Methods and Criteria: Group assignments and examination.
Study Material: Material of the study sessions. Articles related to the study sessions and assignments.
Substitutes for Courses: Replaces former courses CSE-C3600 Software Design and Modelling and T-76.4602 Software Development Methods (6 cr)
Evaluation: 0-5
Registration for Courses: Registration via WebOodi.
Language of Instruction: English

CS-C3180 Software Design and Modelling (5 sp)

Ansvarig lärare: Varvana Myllärniemi; Marjo Kauppinen
Kursens status: Common course of the Software and Service Engineering major (Master's level).
Kursnivå: Master's level
Undervisningsperiod: I-II (Autumn)
Arbetsmängd: Study sessions (lectures): 30h, Workshops and individual work: 40h, Group assignments: 60h

Lärandemål: This course aims to help you learn how to analyze the problem the customer has and how to design a solution that satisfies customer and user needs. You learn to describe the essence of the key software engineering activities and how these activities relate to each other. You are also able to compare modeling methods, assess their applicability for different software engineering activities and select appropriate design practices for the development team. Furthermore, you are able to apply a set of design and modeling methods in practice.
Innehåll: After the course, the student will have a broad understanding of software engineering activities and methods as a whole and have basic skills to participate in software development projects. The software engineering activities covered in this course are: a) requirements engineering, b) domain modeling, c) software architecture design, d) testing, and e) teamwork.
Metoder, arbetssätt och bedömningsgrunder: Group assignments and examination.
Studiematerial: Material of the study sessions. Articles related to the study sessions and assignments.
Bedömningsskala: 0-5
Anmälning: Registration via WebOodi.
Undervisningsspråk: English

CS-C3180 Software Design and Modelling (5 cr)

Responsible teacher: Varvana Myllärniemi; Marjo Kauppinen
Status of the Course: Common course of the Software and Service Engineering major (Master's level).
Level of the Course: Master's level
Teaching Period: I-II (Autumn)
Workload: Study sessions (lectures): 30h, Workshops and individual work: 40h, Group assignments: 60h
Learning Outcomes: This course aims to help you learn how to analyze the problem the customer has and how to design a solution that satisfies customer and user needs. You learn to describe the essence of the key software engineering activities and how these activities relate to each other. You are also able to compare modeling methods, assess their applicability for different software engineering activities and select appropriate design practices for the development team. Furthermore, you are able to apply a set of design and modeling methods in practice.
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Assessment Methods and Criteria: Group assignments and examination.
Study Material: Material of the study sessions. Articles related to the study sessions and assignments.
Grading Scale: 0-5
Registration for Courses: Registration via WebOodi.

Language of Instruction: English

CS-E3190 Principles of Algorithmic Techniques (5 cr)

Responsible teacher: Pekka Orponen
Status of the Course: The course is only for students who have completed their general studies.
Teaching period: I - II (Autumn)
Workload: Lectures: 36h (2x2h/week) Tutorial sessions: 18h (2h/week) Exam: 3h Independent work: 78h (lecture review 24h, tutorial problems 45h, exam priming 9h)
Learning Outcomes: At this course you will become familiar with a number of fundamental structures and principles underlying the design of efficient algorithms, and will learn to approach new algorithmic problems using these generic paradigms. You will also come to appreciate the possibilities and limitations of theoretical a priori analysis of algorithm efficiency, and learn to perform such analyses in simple cases.
Content: Fundamental algorithm design paradigms: divide-and-conquer, greedy algorithms, dynamic programming. Randomised algorithms. Introduction to the analysis of algorithms and the theory of NP-completeness.
Assessment Methods and Criteria: Tutorial problems/assignments (15%) and an exam (85%).
Study Material: S. Dasgupta, C. Papadimitriou, U. Vazirani: Algorithms. McGraw-Hill 2008.
Substitutes for Courses: Replaces the courses T-79.4202 Principles of Algorithmic Techniques and T-106.4100 Design and Analysis of Algorithms.
Prerequisites: First year engineering mathematics, together with an introduction to probability theory (e.g. MS-A05XX), and programming skills (e.g. CS-A111X). Familiarity with basic data structures (e.g. CS-A114X) an asset.
Evaluation: 0-5
Language of Instruction: English.

CS-E3190 Principles of Algorithmic Techniques (5 sp)

Ansvarig lärare: Pekka Orponen
Kursens status: The course is only for students who have completed their general studies.
Undervisningsperiod: I - II (Autumn)
Arbetsmängd: Lectures: 36h (2x2h/week) Tutorial sessions: 18h (2h/week) Exam: 3h Independent work: 78h (lecture review 24h, tutorial problems 45h, exam priming 9h)
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Innehåll: Fundamental algorithm design paradigms: divide-and-conquer, greedy

algorithms, dynamic programming. Randomised algorithms. Introduction to the analysis of algorithms and the theory of NP-completeness.
Metoder, arbetssätt och bedömningsgrunder: Tutorial problems/assignments (15%) and an exam (85%).
Studiematerial: S. Dasgupta, C. Papadimitriou, U. Vazirani: Algorithms. McGraw-Hill 2008.
Ersättande prestationer: Replaces the courses T-79.4202 Principles of Algorithmic Techniques and T-106.4100 Design and Analysis of Algorithms.
Förkunskaper: First year engineering mathematics, together with an introduction to probability theory (e.g. MS-A05XX), and programming skills (e.g. CS-A111X). Familiarity with basic data structures (e.g. CS-A114X) an asset.
Bedömningsskala: 0-5
Undervisningsspråk: English.

CS-E3190 Principles of Algorithmic Techniques (5 cr)

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Status of the Course: The course is only for students who have completed their general studies.
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Study Material: S. Dasgupta, C. Papadimitriou, U. Vazirani: Algorithms. McGraw-Hill 2008.
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Prerequisites: First year engineering mathematics, together with an introduction to probability theory (e.g. MS-A05XX), and programming skills (e.g. CS-A111X). Familiarity with basic data structures (e.g. CS-A114X) an asset.
Grading Scale: 0-5
Language of Instruction: English.

CS-E3200 Discrete Models and Search (5 cr)

Responsible teacher: Tomi Janhunen
Level of the Course: The course is only for students who have completed their

general studies.
Teaching period: III - IV (Spring)
Workload:
Lectures: 22
Teaching in small groups: 22
Exam: 3
Programming assignments: 20
Other independent work (including preparing for the examination): 66
Learning Outcomes: At this course you will learn to represent combinatorial search problems in terms of propositional satisfiability, constraint programming, and integer programming formulations. You will obtain a basic understanding of complete search methods and become familiar with several types of local search techniques. Having completed the course, you will be able to translate your problem into an appropriate general formulation and use a generic problem solver to solve the problem, or design a local search method tailored specifically to your problem of interest.
Content: Search spaces and search methods. Backtracking, local and heuristic search. Representing and solving search problems using propositional satisfiability, constraint programming, and integer programming techniques.
Assessment Methods and Criteria: Examination and programming assignments. The course grade is determined by the exam but bonus points can be earned from programming assignments and tutorial exercises.
Substitutes for Courses: Replaces former courses T-79.4101 Discrete Models and Search and T-79.3001 Logic in Computer Science: Foundations.
Course Homepage: https://mycourses.aalto.fi/course/view.php?id=8899
Prerequisites: Basic algorithmic techniques (e.g. CS-E3190 / T-79.4202 Principles of Algorithmic Techniques), linear algebra, and good programming skills (Python/Java in particular).
Evaluation: 0-5
Language of Instruction: English

CS-E3200 Discrete Models and Search (5 sp)

Ansvarig lärare: Tomi Janhunen
Kursnivå: The course is only for students who have completed their general studies.
Undervisningsperiod: III - IV (Spring)
Arbetsmängd:
Lectures: 22
Teaching in small groups: 22
Exam: 3
Programming assignments: 20
Other independent work (including preparing for the examination): 66
Lärandemål: At this course you will learn to represent combinatorial search problems in terms of propositional satisfiability, constraint programming, and integer programming formulations. You will obtain a basic understanding of complete search methods and become familiar with several types of local search

techniques. Having completed the course, you will be able to translate your problem into an appropriate general formulation and use a generic problem solver to solve the problem, or design a local search method tailored specifically to your problem of interest.
Innehåll: Search spaces and search methods. Backtracking, local and heuristic search. Representing and solving search problems using propositional satisfiability, constraint programming, and integer programming techniques.
Metoder, arbetssätt och bedömningsgrunder: Examination and programming assignments. The course grade is determined by the exam but bonus points can be earned from programming assignments and tutorial exercises.
Ersättande prestationer: Replaces former courses T-79.4101 Discrete Models and Search and T-79.3001 Logic in Computer Science: Foundations.
Kursens webbplats: https://mycourses.aalto.fi/course/view.php?id=8899
Förkunskaper: Basic algorithmic techniques (e.g. CS-E3190 / T-79.4202 Principles of Algorithmic Techniques), linear algebra, and good programming skills (Python/Java in particular).
Bedömningsskala: 0-5
Undervisningsspråk: English

CS-E3200 Discrete Models and Search (5 cr)

Responsible teacher: Tomi Janhunen
Level of the Course: The course is only for students who have completed their general studies.
Teaching Period: III - IV (Spring)
Workload:
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Prerequisites: Basic algorithmic techniques (e.g. CS-E3190 / T-79.4202 Principles of Algorithmic Techniques), linear algebra, and good programming skills (Python/Java in particular).
Grading Scale: 0-5
Language of Instruction: English

CS-E3210 Machine Learning: Basic Principles (5 cr)

Responsible teacher: Samuel Kaski
Teaching period: I-II (Autumn)
Workload: 24 + 24 (2 + 2)
Learning Outcomes: After the course, the student is able to apply the basic machine learning methods to data and to understand new models based on these principles.
Content: The course deals with basic principles needed to understand and apply machine learning models and methods. The topics include supervised and unsupervised learning, Bayesian decision theory, parametric methods, tuning model complexity, dimensionality reduction, clustering, nonparametric methods, decision trees, comparing and combining algorithms, as well as a few applications of these methods.
Assessment Methods and Criteria: Examination and exercise work.
Study Material: To be specified in MyCourses at the start of the course.
Substitutes for Courses: Replaces courses T-61.3050 Machine Learning: Basic Principles and T-61.3030 Principles of Neural Computing.
Prerequisites: Basic mathematics and probability courses.
Evaluation: 0-5
Language of Instruction: English

CS-E3210 Machine Learning: Basic Principles (5 sp)

Ansvarig lärare: Samuel Kaski
Undervisningsperiod: I-II (Autumn)
Arbetsmängd: 24 + 24 (2 + 2)
Lärandemål: After the course, the student is able to apply the basic machine learning methods to data and to understand new models based on these principles.
Innehåll: The course deals with basic principles needed to understand and apply machine learning models and methods. The topics include supervised and unsupervised learning, Bayesian decision theory, parametric methods, tuning model complexity, dimensionality reduction, clustering, nonparametric methods, decision trees, comparing and combining algorithms, as well as a few applications of these methods.
Metoder, arbetssätt och bedömningsgrunder: Examination and exercise work.
Studiematerial: To be specified in MyCourses at the start of the course.
Ersättande prestationer: Replaces courses T-61.3050 Machine Learning: Basic Principles and T-61.3030 Principles of Neural Computing.
Förkunskaper: Basic mathematics and probability courses.
Bedömningsskala: 0-5

Undervisningsspråk: English

CS-E3210 Machine Learning: Basic Principles (5 cr)

Responsible teacher: Samuel Kaski
Teaching Period: I-II (Autumn)
Workload: 24 + 24 (2 + 2)
Learning Outcomes: After the course, the student is able to apply the basic machine learning methods to data and to understand new models based on these principles.
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Assessment Methods and Criteria: Examination and exercise work.
Study Material: To be specified in MyCourses at the start of the course.
Substitutes for Courses: Replaces courses T-61.3050 Machine Learning: Basic Principles and T-61.3030 Principles of Neural Computing.
Prerequisites: Basic mathematics and probability courses.
Grading Scale: 0-5
Language of Instruction: English

CS-E4000 Seminar in Computer Science (5 cr)

Responsible teacher: Mario Di Francesco; Antti Ylä-Jääski
Level of the Course: Master's level
Teaching period: I-II, III-V (Autumn and Spring)
Learning Outcomes: Students gain a deep understanding of an advanced topic in the computer, communication or information sciences. They learn to survey up-to-date research literature and technical documentation on a new topic, to analyze the information critically and to summarize it, to write a technical article in English, and to present it to an engineering audience. The best students are also able to perform experiments to deepen their knowledge of the given topic, to solve a technical or scientific problem, and to present their own results. The course provides many skills that will be useful in the Master's thesis project.
Content: The course addresses a broad range of current topics in the computer, communication and information science areas. Each student writes a technical article in the format of a conference paper, which is published in the seminar proceedings, and presents it in the seminar event at the end of the course. The topics are specified by university researchers and industry experts, and each students is assigned an individual tutor. Doctoral students are required to propose their own research topics.
Assessment Methods and Criteria: Seminar paper, presentation, active participation.
Evaluation: 0-5
Language of Instruction: English

CS-E4000 Seminar in Computer Science (5 sp)

Ansvarig lärare: Mario Di Francesco; Antti Ylä-Jääski
Kursnivå: Master's level
Undervisningsperiod: I-II, III-V (Autumn and Spring)
Lärandemål: Students gain a deep understanding of an advanced topic in the computer, communication or information sciences. They learn to survey up-to-date research literature and technical documentation on a new topic, to analyze the information critically and to summarize it, to write a technical article in English, and to present it to an engineering audience. The best students are also able to perform experiments to deepen their knowledge of the given topic, to solve a technical or scientific problem, and to present their own results. The course provides many skills that will be useful in the Master's thesis project.
Innehåll: The course addresses a broad range of current topics in the computer, communication and information science areas. Each student writes a technical article in the format of a conference paper, which is published in the seminar proceedings, and presents it in the seminar event at the end of the course. The topics are specified by university researchers and industry experts, and each students is assigned an individual tutor. Doctoral students are required to propose their own research topics.
Metoder, arbetssätt och bedömningsgrunder: Seminar paper, presentation, active participation.
Bedömningsskala: 0-5
Undervisningsspråk: English

CS-E4000 Seminar in Computer Science (5 cr)

Responsible teacher: Mario Di Francesco; Antti Ylä-Jääski
Level of the Course: Master's level
Teaching Period: I-II, III-V (Autumn and Spring)
Learning Outcomes: Students gain a deep understanding of an advanced topic in the computer, communication or information sciences. They learn to survey up-to-date research literature and technical documentation on a new topic, to analyze the information critically and to summarize it, to write a technical article in English, and to present it to an engineering audience. The best students are also able to perform experiments to deepen their knowledge of the given topic, to solve a technical or scientific problem, and to present their own results. The course provides many skills that will be useful in the Master's thesis project.
Content: The course addresses a broad range of current topics in the computer, communication and information science areas. Each student writes a technical article in the format of a conference paper, which is published in the seminar proceedings, and presents it in the seminar event at the end of the course. The topics are specified by university researchers and industry experts, and each students is assigned an individual tutor. Doctoral students are required to propose their own research topics.
Assessment Methods and Criteria: Seminar paper, presentation, active participation.

Grading Scale: 0-5
Language of Instruction: English

CS-E4001 Research Seminar in Computer Science(V) (1-10 cr)

Responsible teacher: Keijo Heljanko
Level of the Course: Master's level
Teaching period: I-II, III-V (Autumn and Spring)
Learning Outcomes: Students gain a deep understanding of an advanced topic in the computer, communication or information sciences. They learn to survey up-to-date research literature and technical documentation on a new topic, to analyze the information critically and to summarize it, to write a technical article or to discuss it with an engineering audience. The best students are also able to perform experiments to deepen their knowledge of the given topic, to solve a technical or scientific problem, and to present their own results.
Content: The course addresses a broad range of current topics in the computer, communication and information science areas.
Assessment Methods and Criteria: Active participation, defined in more details in the beginning of the course.
Evaluation: 0-5, may also be graded with pass/fail.
Language of Instruction: English
Further Information: The content of the course varies.

CS-E4001 Research Seminar in Computer Science(V) (1-10 sp)

Ansvarig lärare: Keijo Heljanko
Kursnivå: Master's level
Undervisningsperiod: I-II, III-V (Autumn and Spring)
Lärandemål: Students gain a deep understanding of an advanced topic in the computer, communication or information sciences. They learn to survey up-to-date research literature and technical documentation on a new topic, to analyze the information critically and to summarize it, to write a technical article or to discuss it with an engineering audience. The best students are also able to perform experiments to deepen their knowledge of the given topic, to solve a technical or scientific problem, and to present their own results.
Innehåll: The course addresses a broad range of current topics in the computer, communication and information science areas.
Metoder, arbetssätt och bedömningsgrunder: Active participation, defined in more details in the beginning of the course.
Bedömningsskala: 0-5, may also be graded with pass/fail.
Undervisningsspråk: English
Tilläggsinformation: The content of the course varies.

CS-E4001 Research Seminar in Computer Science(V) (1-10 cr)

Responsible teacher: Keijo Heljanko
Level of the Course: Master's level
Teaching Period: I-II, III-V (Autumn and Spring)

Learning Outcomes: Students gain a deep understanding of an advanced topic in the computer, communication or information sciences. They learn to survey up-to-date research literature and technical documentation on a new topic, to analyze the information critically and to summarize it, to write a technical article or to discuss it with an engineering audience. The best students are also able to perform experiments to deepen their knowledge of the given topic, to solve a technical or scientific problem, and to present their own results.
Content: The course addresses a broad range of current topics in the computer, communication and information science areas.
Assessment Methods and Criteria: Active participation, defined in more details in the beginning of the course.
Grading Scale: 0-5, may also be graded with pass/fail.
Language of Instruction: English
Further Information: The content of the course varies.

CS-E4002 Special Course in Computer Science(V) (1-10 cr)

Level of the Course: Master's level
Teaching period: Announced later.
Learning Outcomes: You are familiar with some scientifically or technically demanding topic.
Content: This course has a varying topic. The content of the course is a selected current topic areas in communication, computer and information sciences. When arranged, the course may be given in English. Information about the arrangement and the beginning of the course will be published in the web pages.
Assessment Methods and Criteria: Announced later.
Evaluation: 0-5, may also be graded with pass/fail.
Further Information: The content of the course varies.

CS-E4002 Special Course in Computer Science(V) (1-10 sp)

Kursnivå: Master's level
Undervisningsperiod: Announced later.
Lärandemål: You are familiar with some scientifically or technically demanding topic.
Innehåll: This course has a varying topic. The content of the course is a selected current topic areas in communication, computer and information sciences. When arranged, the course may be given in English. Information about the arrangement and the beginning of the course will be published in the web pages.
Metoder, arbetssätt och bedömningsgrunder: Announced later.
Bedömningsskala: 0-5, may also be graded with pass/fail.
Tilläggsinformation: The content of the course varies.

CS-E4002 Special Course in Computer Science(V) (1-10 cr)

Level of the Course: Master's level
Teaching Period: Announced later.
Learning Outcomes: You are familiar with some scientifically or technically

demanding topic.
Content: This course has a varying topic. The content of the course is a selected current topic areas in communication, computer and information sciences. When arranged, the course may be given in English. Information about the arrangement and the beginning of the course will be published in the web pages.
Assessment Methods and Criteria: Announced later.
Grading Scale: 0-5, may also be graded with pass/fail.
Further Information: The content of the course varies.

CS-E4003 Special Assignment in Computer Science(V) (1-10 cr)

Responsible teacher: Petri Vuorimaa
Level of the Course: Master's level
Teaching period: Agreed with the teacher.
Learning Outcomes: You have experience in defining, analyzing and solving a demanding technical question. You know how to find and use relevant documentation, standards and scientific literature. You are able to document your work clearly.
Content: Independent technical or scientific research or software project in the field of computer, communication or information sciences. With a prior agreement, the work can be carried out in groups.
Assessment Methods and Criteria: Preparation, reporting and presentation of a research or software project.
Evaluation: 0-5, may also be graded with pass/fail.
Further Information: The content of the course varies. Any professor of CS department can act as a teacher of this course. More information in MyCourses.

CS-E4003 Special Assignment in Computer Science(V) (1-10 sp)

Ansvarig lärare: Petri Vuorimaa
Kursnivå: Master's level
Undervisningsperiod: Agreed with the teacher.
Lärandemål: You have experience in defining, analyzing and solving a demanding technical question. You know how to find and use relevant documentation, standards and scientific literature. You are able to document your work clearly.
Innehåll: Independent technical or scientific research or software project in the field of computer, communication or information sciences. With a prior agreement, the work can be carried out in groups.
Metoder, arbetssätt och bedömningsgrunder: Preparation, reporting and presentation of a research or software project.
Bedömningsskala: 0-5, may also be graded with pass/fail.
Tilläggsinformation: The content of the course varies. Any professor of CS department can act as a teacher of this course. More information in MyCourses.

CS-E4003 Special Assignment in Computer Science(V) (1-10 cr)

Responsible teacher: Petri Vuorimaa

Level of the Course: Master's level
Teaching Period: Agreed with the teacher.
Learning Outcomes: You have experience in defining, analyzing and solving a demanding technical question. You know how to find and use relevant documentation, standards and scientific literature. You are able to document your work clearly.
Content: Independent technical or scientific research or software project in the field of computer, communication or information sciences. With a prior agreement, the work can be carried out in groups.
Assessment Methods and Criteria: Preparation, reporting and presentation of a research or software project.
Grading Scale: 0-5, may also be graded with pass/fail.
Further Information: The content of the course varies. Any professor of CS department can act as a teacher of this course. More information in MyCourses.

CS-E4004 Individual Studies in Computer Science(V) (1-10 cr)

Responsible teacher: Petri Vuorimaa
Level of the Course: Master's level
Teaching period: Agreed with the teacher.
Learning Outcomes: You have experience in defining, analyzing and solving a demanding technical question. You know how to find and use relevant documentation, standards and scientific literature. You are able to document your work clearly.
Content: Independent technical or scientific research or software project in the field of computer, communication or information sciences. Can also be a literature survey on an advanced topic. With a prior agreement, the work can be carried out in groups.
Assessment Methods and Criteria: Preparation, reporting and presentation of a research or software project.
Evaluation: 0-5, may also be graded with pass/fail.
Further Information: The content of the course varies. Any professor of CS department can act as a teacher of this course. More information in MyCourses.

CS-E4004 Individual Studies in Computer Science(V) (1-10 sp)

Ansvarig lärare: Petri Vuorimaa
Kursnivå: Master's level
Undervisningsperiod: Agreed with the teacher.
Lärandemål: You have experience in defining, analyzing and solving a demanding technical question. You know how to find and use relevant documentation, standards and scientific literature. You are able to document your work clearly.
Innehåll: Independent technical or scientific research or software project in the field of computer, communication or information sciences. Can also be a literature survey on an advanced topic. With a prior agreement, the work can be carried out in groups.
Metoder, arbetssätt och bedömningsgrunder: Preparation, reporting and

presentation of a research or software project.
Bedömningsskala: 0-5, may also be graded with pass/fail.
Tilläggsinformation: The content of the course varies. Any professor of CS department can act as a teacher of this course. More information in MyCourses.

CS-E4004 Individual Studies in Computer Science(V) (1-10 cr)

Responsible teacher: Petri Vuorimaa
Level of the Course: Master's level
Teaching Period: Agreed with the teacher.
Learning Outcomes: You have experience in defining, analyzing and solving a demanding technical question. You know how to find and use relevant documentation, standards and scientific literature. You are able to document your work clearly.
Content: Independent technical or scientific research or software project in the field of computer, communication or information sciences. Can also be a literature survey on an advanced topic. With a prior agreement, the work can be carried out in groups.
Assessment Methods and Criteria: Preparation, reporting and presentation of a research or software project.
Grading Scale: 0-5, may also be graded with pass/fail.
Further Information: The content of the course varies. Any professor of CS department can act as a teacher of this course. More information in MyCourses.

CS-E4005 Methods and Tools for Network Systems (5 cr)

Responsible teacher: Mario Di Francesco
Status of the Course: Compulsory course of the Mobile Computing, Services and Security major.
Level of the Course: Master's level
Teaching period: I (Fall)
Learning Outcomes: After successful completion of the course, you will be able to: describe the most important methodologies for network systems; use software tools to address concrete problems in computing and networking; find research papers and technical documentation; identify the methodologies employed by existing solutions; analyze the strengths and weaknesses of different methods in specific scenarios.
Content: Methodologies and technical approaches for network systems: computer simulation, mathematical modeling, data analysis, experimental evaluation. Examples of software tools for the different methodologies. Accessing and evaluating research literature and technical documentation from different sources.
Assessment Methods and Criteria: Weekly exercises.
Substitutes for Courses: This course replaces the courses CSE-E4430 Methods and Tools for Network Systems and T-110.6130 Systems Engineering in Data Communications Software L.
Prerequisites: Basic computer programming skills, basic knowledge of network technologies and mathematics for computer science.
Evaluation: 0-5

Language of Instruction: English
Further Information: This course is mandatory for first-year master students who completed their bachelor degree in another university and are currently enrolled in either NordSecMob – the Master's Programme in Mobile Computing. Services and Security – or Data Communications Software. As a methodological course, it is recommended for all students who specialize in data communications software.

CS-E4005 Methods and Tools for Network Systems (5 sp)

Ansvarig lärare: Mario Di Francesco
Kursens status: Compulsory course of the Mobile Computing, Services and Security major.
Kursnivå: Master's level
Undervisningsperiod: I (Fall)
Lärandemål: After successful completion of the course, you will be able to: describe the most important methodologies for network systems; use software tools to address concrete problems in computing and networking; find research papers and technical documentation; identify the methodologies employed by existing solutions; analyze the strengths and weaknesses of different methods in specific scenarios.
Innehåll: Methodologies and technical approaches for network systems: computer simulation, mathematical modeling, data analysis, experimental evaluation. Examples of software tools for the different methodologies. Accessing and evaluating research literature and technical documentation from different sources.
Metoder, arbetssätt och bedömningsgrunder: Weekly exercises.
Ersättande prestationer: This course replaces the courses CSE-E4430 Methods and Tools for Network Systems and T-110.6130 Systems Engineering in Data Communications Software L.
Förkunskaper: Basic computer programming skills, basic knowledge of network technologies and mathematics for computer science.
Bedömningsskala: 0-5
Undervisningsspråk: English
Tilläggsinformation: This course is mandatory for first-year master students who completed their bachelor degree in another university and are currently enrolled in either NordSecMob – the Master's Programme in Mobile Computing. Services and Security – or Data Communications Software. As a methodological course, it is recommended for all students who specialize in data communications software.

CS-E4005 Methods and Tools for Network Systems (5 cr)

Responsible teacher: Mario Di Francesco
Status of the Course: Compulsory course of the Mobile Computing, Services and Security major.
Level of the Course: Master's level
Teaching Period: I (Fall)
Learning Outcomes: After successful completion of the course, you will be able

to: describe the most important methodologies for network systems; use software tools to address concrete problems in computing and networking; find research papers and technical documentation; identify the methodologies employed by existing solutions; analyze the strengths and weaknesses of different methods in specific scenarios.
Content: Methodologies and technical approaches for network systems: computer simulation, mathematical modeling, data analysis, experimental evaluation. Examples of software tools for the different methodologies. Accessing and evaluating research literature and technical documentation from different sources.
Assessment Methods and Criteria: Weekly exercises.
Substitutes for Courses: This course replaces the courses CSE-E4430 Methods and Tools for Network Systems and T-110.6130 Systems Engineering in Data Communications Software L.
Prerequisites: Basic computer programming skills, basic knowledge of network technologies and mathematics for computer science.
Grading Scale: 0-5
Language of Instruction: English
Further Information: This course is mandatory for first-year master students who completed their bachelor degree in another university and are currently enrolled in either NordSecMob – the Master's Programme in Mobile Computing. Services and Security – or Data Communications Software. As a methodological course, it is recommended for all students who specialize in data communications software.

CS-E4010 Special Course in Machine Learning and Data Science I(V) (3-10 cr)

Responsible teacher: Heikki Mannila; Aristides Gionis; Samuel Kaski; Harri Lähdesmäki; Alex Jung; Aki Vehtari; Juho Rousu; Jouko Lampinen; Juha Karhunen; Tapani Raiko
Teaching period: I-V
Content: Postgraduate level knowledge from one of the fields of computer and information science. The actual contents of the course vary from year to year. The course can be lectured, or arranged in seminar form.
Assessment Methods and Criteria: To be specified at the start of the course.
Study Material: Usually some new study book or collection of articles.
Substitutes for Courses: T-61.6010 Special Course in Computer and Information Science I
Evaluation: 0-5, may be graded with pass/fail
Language of Instruction: English
Further Information: The contents of the course vary.

CS-E4010 Special Course in Machine Learning and Data Science I(V) (3-10 sp)

Ansvarig lärare: Heikki Mannila; Aristides Gionis; Samuel Kaski; Harri Lähdesmäki; Alex Jung; Aki Vehtari; Juho Rousu; Jouko Lampinen; Juha Karhunen; Tapani Raiko

Undervisningsperiod: I-V
Innehåll: Postgraduate level knowledge from one of the fields of computer and information science. The actual contents of the course vary from year to year. The course can be lectured, or arranged in seminar form.
Metoder, arbetssätt och bedömningsgrunder: To be specified at the start of the course.
Studiematerial: Usually some new study book or collection of articles.
Ersättande prestationer: T-61.6010 Special Course in Computer and Information Science I
Bedömningsskala: 0-5, may be graded with pass/fail
Undervisningsspråk: English
Tilläggsinformation: The contents of the course vary.

CS-E4010 Special Course in Machine Learning and Data Science I(V) (3-10 cr)

Responsible teacher: Heikki Mannila; Aristides Gionis; Samuel Kaski; Harri Lähdesmäki; Alex Jung; Aki Vehtari; Juho Rousu; Jouko Lampinen; Juha Karhunen; Tapani Raiko
Teaching Period: I-V
Content: Postgraduate level knowledge from one of the fields of computer and information science. The actual contents of the course vary from year to year. The course can be lectured, or arranged in seminar form.
Assessment Methods and Criteria: To be specified at the start of the course.
Study Material: Usually some new study book or collection of articles.
Substitutes for Courses: T-61.6010 Special Course in Computer and Information Science I
Grading Scale: 0-5, may be graded with pass/fail
Language of Instruction: English
Further Information: The contents of the course vary.

CS-E4020 Special Course in Machine Learning and Data Science II(V) (3-10 cr)

Responsible teacher: Heikki Mannila; Aristides Gionis; Samuel Kaski; Harri Lähdesmäki; Alex Jung; Aki Vehtari; Juho Rousu; Jouko Lampinen; Juha Karhunen; Tapani Raiko
Teaching period: I-V
Content: Postgraduate level knowledge from one of the fields of computer and information science. The actual contents of the course vary from year to year. The course can be lectured, or arranged in seminar form.
Assessment Methods and Criteria: To be specified at the start of the course.
Study Material: Usually some new study book or collection of articles.
Substitutes for Courses: T-61.6020 Special Course in Computer and Information Science II
Evaluation: 0-5, may be graded with pass/fail
Language of Instruction: English
Further Information: The contents of the course vary.

CS-E4020 Special Course in Machine Learning and Data Science II(V) (3-10 sp)

Ansvarig lärare: Heikki Mannila; Aristides Gionis; Samuel Kaski; Harri Lähdesmäki; Alex Jung; Aki Vehtari; Juho Rousu; Jouko Lampinen; Juha Karhunen; Tapani Raiko
Undervisningsperiod: I-V
Innehåll: Postgraduate level knowledge from one of the fields of computer and information science. The actual contents of the course vary from year to year. The course can be lectured, or arranged in seminar form.
Metoder, arbetssätt och bedömningsgrunder: To be specified at the start of the course.
Studiematerial: Usually some new study book or collection of articles.
Ersättande prestationer: T-61.6020 Special Course in Computer and Information Science II
Bedömningsskala: 0-5, may be graded with pass/fail
Undervisningsspråk: English
Tilläggsinformation: The contents of the course vary.

CS-E4020 Special Course in Machine Learning and Data Science II(V) (3-10 cr)

Responsible teacher: Heikki Mannila; Aristides Gionis; Samuel Kaski; Harri Lähdesmäki; Alex Jung; Aki Vehtari; Juho Rousu; Jouko Lampinen; Juha Karhunen; Tapani Raiko
Teaching Period: I-V
Content: Postgraduate level knowledge from one of the fields of computer and information science. The actual contents of the course vary from year to year. The course can be lectured, or arranged in seminar form.
Assessment Methods and Criteria: To be specified at the start of the course.
Study Material: Usually some new study book or collection of articles.
Substitutes for Courses: T-61.6020 Special Course in Computer and Information Science II
Grading Scale: 0-5, may be graded with pass/fail
Language of Instruction: English
Further Information: The contents of the course vary.

CS-E4030 Special Course in Machine Learning and Data Science III(V) (3-10 cr)

Responsible teacher: Heikki Mannila; Aristides Gionis; Samuel Kaski; Harri Lähdesmäki; Alex Jung; Aki Vehtari; Juho Rousu; Jouko Lampinen; Juha Karhunen; Tapani Raiko
Teaching period: I-V
Content: Postgraduate level knowledge from one of the fields of computer and information science. The actual contents of the course vary from year to year. The course can be lectured, or arranged in seminar form.

Assessment Methods and Criteria: To be specified at the start of the course.
Study Material: Usually some new study book or collection of articles.
Substitutes for Courses: T-61.6020 Special Course in Computer and Information Science III
Evaluation: 0-5, may be graded with pass/fail
Language of Instruction: English
Further Information: The contents of the course vary.

CS-E4030 Special Course in Machine Learning and Data Science III(V) (3-10 sp)

Ansvarig lärare: Heikki Mannila; Aristides Gionis; Samuel Kaski; Harri Lähdesmäki; Alex Jung; Aki Vehtari; Juho Rousu; Jouko Lampinen; Juha Karhunen; Tapani Raiko
Undervisningsperiod: I-V
Innehåll: Postgraduate level knowledge from one of the fields of computer and information science. The actual contents of the course vary from year to year. The course can be lectured, or arranged in seminar form.
Metoder, arbetssätt och bedömningsgrunder: To be specified at the start of the course.
Studiematerial: Usually some new study book or collection of articles.
Ersättande prestationer: T-61.6020 Special Course in Computer and Information Science III
Bedömningsskala: 0-5, may be graded with pass/fail
Undervisningsspråk: English
Tilläggsinformation: The contents of the course vary.

CS-E4030 Special Course in Machine Learning and Data Science III(V) (3-10 cr)

Responsible teacher: Heikki Mannila; Aristides Gionis; Samuel Kaski; Harri Lähdesmäki; Alex Jung; Aki Vehtari; Juho Rousu; Jouko Lampinen; Juha Karhunen; Tapani Raiko
Teaching Period: I-V
Content: Postgraduate level knowledge from one of the fields of computer and information science. The actual contents of the course vary from year to year. The course can be lectured, or arranged in seminar form.
Assessment Methods and Criteria: To be specified at the start of the course.
Study Material: Usually some new study book or collection of articles.
Substitutes for Courses: T-61.6020 Special Course in Computer and Information Science III
Grading Scale: 0-5, may be graded with pass/fail
Language of Instruction: English
Further Information: The contents of the course vary.

CS-E4040 Special Course in Machine Learning and Data Science IV(V) (3-10 cr)

Responsible teacher: Heikki Mannila; Aristides Gionis; Samuel Kaski; Harri Lähdesmäki; Alex Jung; Aki Vehtari; Juho Rousu; Jouko Lampinen; Juha Karhunen; Tapani Raiko
Teaching period: I-V
Content: Postgraduate level knowledge from one of the fields of computer and information science. The actual contents of the course vary from year to year. The course can be lectured, or arranged in seminar form.
Assessment Methods and Criteria: To be specified at the start of the course.
Study Material: Usually some new study book or collection of articles.
Substitutes for Courses: T-61.6020 Special Course in Computer and Information Science IV
Evaluation: 0-5, may be graded with pass/fail
Language of Instruction: English
Further Information: The contents of the course vary.

CS-E4040 Special Course in Machine Learning and Data Science IV(V) (3-10 sp)

Ansvarig lärare: Heikki Mannila; Aristides Gionis; Samuel Kaski; Harri Lähdesmäki; Alex Jung; Aki Vehtari; Juho Rousu; Jouko Lampinen; Juha Karhunen; Tapani Raiko
Undervisningsperiod: I-V
Innehåll: Postgraduate level knowledge from one of the fields of computer and information science. The actual contents of the course vary from year to year. The course can be lectured, or arranged in seminar form.
Metoder, arbetssätt och bedömningsgrunder: To be specified at the start of the course.
Studiematerial: Usually some new study book or collection of articles.
Ersättande prestationer: T-61.6020 Special Course in Computer and Information Science IV
Bedömningsskala: 0-5, may be graded with pass/fail
Undervisningsspråk: English
Tilläggsinformation: The contents of the course vary.

CS-E4040 Special Course in Machine Learning and Data Science IV(V) (3-10 cr)

Responsible teacher: Heikki Mannila; Aristides Gionis; Samuel Kaski; Harri Lähdesmäki; Alex Jung; Aki Vehtari; Juho Rousu; Jouko Lampinen; Juha Karhunen; Tapani Raiko
Teaching Period: I-V
Content: Postgraduate level knowledge from one of the fields of computer and information science. The actual contents of the course vary from year to year. The course can be lectured, or arranged in seminar form.
Assessment Methods and Criteria: To be specified at the start of the course.
Study Material: Usually some new study book or collection of articles.
Substitutes for Courses: T-61.6020 Special Course in Computer and Information Science IV

Grading Scale: 0-5, may be graded with pass/fail
Language of Instruction: English
Further Information: The contents of the course vary.

CS-E4050 Special Course in Machine Learning and Data Science V(V) (3-10 cr)

Responsible teacher: Heikki Mannila; Aristides Gionis; Samuel Kaski; Harri Lähdesmäki; Alex Jung; Aki Vehtari; Juho Rousu; Jouko Lampinen; Juha Karhunen; Tapani Raiko
Teaching period: I-V
Content: Postgraduate level knowledge from one of the fields of computer and information science. The actual contents of the course vary from year to year. The course can be lectured, or arranged in seminar form.
Assessment Methods and Criteria: To be specified at the start of the course.
Study Material: Usually some new study book or collection of articles.
Substitutes for Courses: T-61.6020 Special Course in Computer and Information Science V
Evaluation: 0-5, may be graded with pass/fail
Language of Instruction: English
Further Information: The contents of the course vary.

CS-E4050 Special Course in Machine Learning and Data Science V(V) (3-10 sp)

Ansvarig lärare: Heikki Mannila; Aristides Gionis; Samuel Kaski; Harri Lähdesmäki; Alex Jung; Aki Vehtari; Juho Rousu; Jouko Lampinen; Juha Karhunen; Tapani Raiko
Undervisningsperiod: I-V
Innehåll: Postgraduate level knowledge from one of the fields of computer and information science. The actual contents of the course vary from year to year. The course can be lectured, or arranged in seminar form.
Metoder, arbetssätt och bedömningsgrunder: To be specified at the start of the course.
Studiematerial: Usually some new study book or collection of articles.
Ersättande prestationer: T-61.6020 Special Course in Computer and Information Science V
Bedömningsskala: 0-5, may be graded with pass/fail
Undervisningsspråk: English
Tilläggsinformation: The contents of the course vary.

CS-E4050 Special Course in Machine Learning and Data Science V(V) (3-10 cr)

Responsible teacher: Heikki Mannila; Aristides Gionis; Samuel Kaski; Harri Lähdesmäki; Alex Jung; Aki Vehtari; Juho Rousu; Jouko Lampinen; Juha Karhunen; Tapani Raiko
Teaching Period: I-V

Content: Postgraduate level knowledge from one of the fields of computer and information science. The actual contents of the course vary from year to year. The course can be lectured, or arranged in seminar form.
Assessment Methods and Criteria: To be specified at the start of the course.
Study Material: Usually some new study book or collection of articles.
Substitutes for Courses: T-61.6020 Special Course in Computer and Information Science V
Grading Scale: 0-5, may be graded with pass/fail
Language of Instruction: English
Further Information: The contents of the course vary.

CS-E4060 Special Course in Machine Learning and Data Science VI(V) (3-10 cr)

Responsible teacher: Heikki Mannila; Aristides Gionis; Samuel Kaski; Harri Lähdesmäki; Alex Jung; Aki Vehtari; Juho Rousu; Jouko Lampinen; Juha Karhunen; Tapani Raiko
Teaching period: I-V
Content: Postgraduate level knowledge from one of the fields of computer and information science. The actual contents of the course vary from year to year. The course can be lectured, or arranged in seminar form.
Assessment Methods and Criteria: To be specified at the start of the course.
Study Material: Usually some new study book or collection of articles.
Substitutes for Courses: T-61.6020 Special Course in Computer and Information Science VI
Evaluation: 0-5, may be graded with pass/fail
Language of Instruction: English
Further Information: The contents of the course vary.

CS-E4060 Special Course in Machine Learning and Data Science VI(V) (3-10 sp)

Ansvarig lärare: Heikki Mannila; Aristides Gionis; Samuel Kaski; Harri Lähdesmäki; Alex Jung; Aki Vehtari; Juho Rousu; Jouko Lampinen; Juha Karhunen; Tapani Raiko
Undervisningsperiod: I-V
Innehåll: Postgraduate level knowledge from one of the fields of computer and information science. The actual contents of the course vary from year to year. The course can be lectured, or arranged in seminar form.
Metoder, arbetssätt och bedömningsgrunder: To be specified at the start of the course.
Studiematerial: Usually some new study book or collection of articles.
Ersättande prestationer: T-61.6020 Special Course in Computer and Information Science VI
Bedömningsskala: 0-5, may be graded with pass/fail
Undervisningsspråk: English
Tilläggsinformation: The contents of the course vary.

CS-E4060 Special Course in Machine Learning and Data Science VI(V) (3-10 cr)

Responsible teacher: Heikki Mannila; Aristides Gionis; Samuel Kaski; Harri Lähdesmäki; Alex Jung; Aki Vehtari; Juho Rousu; Jouko Lampinen; Juha Karhunen; Tapani Raiko
Teaching Period: I-V
Content: Postgraduate level knowledge from one of the fields of computer and information science. The actual contents of the course vary from year to year. The course can be lectured, or arranged in seminar form.
Assessment Methods and Criteria: To be specified at the start of the course.
Study Material: Usually some new study book or collection of articles.
Substitutes for Courses: T-61.6020 Special Course in Computer and Information Science VI
Grading Scale: 0-5, may be graded with pass/fail
Language of Instruction: English
Further Information: The contents of the course vary.

CS-E4100 Mobile Cloud Computing (5 cr)

Responsible teacher: Mario Di Francesco
Level of the Course: Master's level
Teaching period: I - II (Fall)
Learning Outcomes: After successful completion of the course, you will be able to: describe the distinctive features of mobile applications; explain how mobile applications can be supported by a cloud computing infrastructure; distinguish between different forms of virtualization; manage the resources offered by cloud computing platforms; write a mobile application that leverages cloud computing; evaluate the suitability of different cloud delivery models for specific application scenarios involving mobile computing.
Content: Principles of mobile computing. Distributed applications and services. Cloud computing and virtualization. Managing and using resources offered by cloud service providers. Computation offloading and thin-client computing. Application scenarios and selected use cases.
Assessment Methods and Criteria: Project work and assignments.
Substitutes for Courses: T-110.5121 Mobile Cloud Computing
Prerequisites: CSE-C2400 Computer Networks or equivalent skills. Basic mobile or web application programming skills.
Evaluation: 0-5
Language of Instruction: English

CS-E4100 Mobile Cloud Computing (5 sp)

Ansvarig lärare: Mario Di Francesco
Kursnivå: Master's level
Undervisningsperiod: I - II (Fall)
Lärandemål: After successful completion of the course, you will be able to: describe the distinctive features of mobile applications; explain how mobile

applications can be supported by a cloud computing infrastructure; distinguish between different forms of virtualization; manage the resources offered by cloud computing platforms; write a mobile application that leverages cloud computing; evaluate the suitability of different cloud delivery models for specific application scenarios involving mobile computing.
Innehåll: Principles of mobile computing. Distributed applications and services. Cloud computing and virtualization. Managing and using resources offered by cloud service providers. Computation offloading and thin-client computing. Application scenarios and selected use cases.
Metoder, arbetssätt och bedömningsgrunder: Project work and assignments.
Ersättande prestationer: T-110.5121 Mobile Cloud Computing
Förkunskaper: CSE-C2400 Computer Networks or equivalent skills. Basic mobile or web application programming skills.
Bedömningsskala: 0-5
Undervisningsspråk: English

CS-E4100 Mobile Cloud Computing (5 cr)

Responsible teacher: Mario Di Francesco
Level of the Course: Master's level
Teaching Period: I - II (Fall)
Learning Outcomes: After successful completion of the course, you will be able to: describe the distinctive features of mobile applications; explain how mobile applications can be supported by a cloud computing infrastructure; distinguish between different forms of virtualization; manage the resources offered by cloud computing platforms; write a mobile application that leverages cloud computing; evaluate the suitability of different cloud delivery models for specific application scenarios involving mobile computing.
Content: Principles of mobile computing. Distributed applications and services. Cloud computing and virtualization. Managing and using resources offered by cloud service providers. Computation offloading and thin-client computing. Application scenarios and selected use cases.
Assessment Methods and Criteria: Project work and assignments.
Substitutes for Courses: T-110.5121 Mobile Cloud Computing
Prerequisites: CSE-C2400 Computer Networks or equivalent skills. Basic mobile or web application programming skills.
Grading Scale: 0-5
Language of Instruction: English

CS-E4110 Concurrent Programming (5 cr)

Responsible teacher: Keijo Heljanko
Level of the Course: Master's level
Teaching period: I - II (Autumn)
Workload: Lectures: 24 (2), Teaching in small groups: 12 (1), Independent work: 96
Learning Outcomes: You are aware of how easily fatal, hard to identify and innocent looking bugs creep in to the code of concurrently running programs. You

can apply general design principles, models and methods to construct concurrent systems that, in addition to all other requirements, behave correctly with the respect to their functional specifications. You have got an experience of applying the theories using the concurrency features of Java and Scala in programming exercises. You know weak memory models, tools for finding concurrency bugs, and modern concurrent programming frameworks such as Akka Actors and Apache Spark.
Content: Principles of concurrent programming, synchronization and communication mechanism. Concurrent and distributed algorithms,. Concurrent and distributed systems.
Assessment Methods and Criteria: Lectures, examination and programming exercises. Course feedback.
Study Material: Lecture slides and handouts
Substitutes for Courses: T-106.5600 Concurrent Programming
Prerequisites: Principles of computer architecture, operating system and run-time system from software perspective. Eg. CS-A1120 / ICS-A1120 Programming 2. Java and Scala programming experience.
Evaluation: 0-5
Language of Instruction: English

CS-E4110 Concurrent Programming (5 sp)

Ansvarig lärare: Keijo Heljanko
Kursnivå: Master's level
Undervisningsperiod: I - II (Autumn)
Arbetsmängd: Lectures: 24 (2), Teaching in small groups: 12 (1), Independent work: 96
Lärandemål: You are aware of how easily fatal, hard to identify and innocent looking bugs creep in to the code of concurrently running programs. You can apply general design principles, models and methods to construct concurrent systems that, in addition to all other requirements, behave correctly with the respect to their functional specifications. You have got an experience of applying the theories using the concurrency features of Java and Scala in programming exercises. You know weak memory models, tools for finding concurrency bugs, and modern concurrent programming frameworks such as Akka Actors and Apache Spark.
Innehåll: Principles of concurrent programming, synchronization and communication mechanism. Concurrent and distributed algorithms,. Concurrent and distributed systems.
Metoder, arbetssätt och bedömningsgrunder: Lectures, examination and programming exercises. Course feedback.
Studiematerial: Lecture slides and handouts
Ersättande prestationer: T-106.5600 Concurrent Programming
Förkunskaper: Principles of computer architecture, operating system and run-time system from software perspective. Eg. CS-A1120 / ICS-A1120 Programming 2. Java and Scala programming experience.
Bedömningsskala: 0-5

Undervisningsspråk: English

CS-E4110 Concurrent Programming (5 cr)

Responsible teacher: Keijo Heljanko
Level of the Course: Master's level
Teaching Period: I - II (Autumn)
Workload: Lectures: 24 (2), Teaching in small groups: 12 (1), Independent work: 96
Learning Outcomes: You are aware of how easily fatal, hard to identify and innocent looking bugs creep in to the code of concurrently running programs. You can apply general design principles, models and methods to construct concurrent systems that, in addition to all other requirements, behave correctly with the respect to their functional specifications. You have got an experience of applying the theories using the concurrency features of Java and Scala in programming exercises. You know weak memory models, tools for finding concurrency bugs, and modern concurrent programming frameworks such as Akka Actors and Apache Spark.
Content: Principles of concurrent programming, synchronization and communication mechanism. Concurrent and distributed algorithms,. Concurrent and distributed systems.
Assessment Methods and Criteria: Lectures, examination and programming exercises. Course feedback.
Study Material: Lecture slides and handouts
Substitutes for Courses: T-106.5600 Concurrent Programming
Prerequisites: Principles of computer architecture, operating system and run-time system from software perspective. Eg. CS-A1120 / ICS-A1120 Programming 2. Java and Scala programming experience.
Grading Scale: 0-5
Language of Instruction: English

CS-E4120 Scalable Cloud Computing (5 cr)

Responsible teacher: Keijo Heljanko
Status of the Course: Compulsory course of the Big Data and Large-Scale Computing track in the Computer Science and Engineering major.
Level of the Course: Master's level
Teaching period: I-II
Workload: Lectures: 24 (2), Teaching in small groups: 12 (1), Independent work: 96
Learning Outcomes: This course focuses on advanced scalable cloud computing technologies and on key algorithmic ideas and methods used to implement them. After completing this course you are able to list many of the key technologies used in big data processing and to select suitable methods for solving challenging big data processing tasks using cloud computing technologies. You will also be able to compare the scalability and fault tolerance implications of using the selected methodologies.
Content: Advanced topics in cloud computing with emphasis on scalable

distributed computing technologies employed in cloud computing. Key cloud technologies and their algorithmic background. Main topics are distributed file systems, distributed batch processing with the MapReduce and the Apache Spark computing frameworks, and distributed cloud based databases.
Assessment Methods and Criteria: Exam and home assignments. Course feedback.
Study Material: Lecture slides, tutorial assignments and their answers.
Substitutes for Courses: Replaces former courses CSE-E5430 / T-79.5308 Scalable Cloud Computing and T-79.5307 Distributed Computing.
Prerequisites: Basic programming skills (CS(E)-A1110 Programming 1). Familiarity with basic data structures (CS(E)-A1140 Data Structures and Algorithms or CS-E3190 / T-79.4202 Principles of Algorithmic Techniques) an asset.
Evaluation: 0-5
Language of Instruction: English

CS-E4120 Scalable Cloud Computing (5 sp)

Ansvarig lärare: Keijo Heljanko
Kursens status: Compulsory course of the Big Data and Large-Scale Computing track in the Computer Science and Engineering major.
Kursnivå: Master's level
Undervisningsperiod: I-II
Arbetsmängd: Lectures: 24 (2), Teaching in small groups: 12 (1), Independent work: 96
Lärandemål: This course focuses on advanced scalable cloud computing technologies and on key algorithmic ideas and methods used to implement them. After completing this course you are able to list many of the key technologies used in big data processing and to select suitable methods for solving challenging big data processing tasks using cloud computing technologies. You will also be able to compare the scalability and fault tolerance implications of using the selected methodologies.
Innehåll: Advanced topics in cloud computing with emphasis on scalable distributed computing technologies employed in cloud computing. Key cloud technologies and their algorithmic background. Main topics are distributed file systems, distributed batch processing with the MapReduce and the Apache Spark computing frameworks, and distributed cloud based databases.
Metoder, arbetssätt och bedömningsgrunder: Exam and home assignments. Course feedback.
Studiematerial: Lecture slides, tutorial assignments and their answers.
Ersättande prestationer: Replaces former courses CSE-E5430 / T-79.5308 Scalable Cloud Computing and T-79.5307 Distributed Computing.
Förkunskaper: Basic programming skills (CS(E)-A1110 Programming 1). Familiarity with basic data structures (CS(E)-A1140 Data Structures and Algorithms or CS-E3190 / T-79.4202 Principles of Algorithmic Techniques) an asset.
Bedömningsskala: 0-5

Undervisningsspråk: English

CS-E4120 Scalable Cloud Computing (5 cr)

Responsible teacher: Keijo Heljanko
Status of the Course: Compulsory course of the Big Data and Large-Scale Computing track in the Computer Science and Engineering major.
Level of the Course: Master's level
Teaching Period: I-II
Workload: Lectures: 24 (2), Teaching in small groups: 12 (1), Independent work: 96
Learning Outcomes: This course focuses on advanced scalable cloud computing technologies and on key algorithmic ideas and methods used to implement them. After completing this course you are able to list many of the key technologies used in big data processing and to select suitable methods for solving challenging big data processing tasks using cloud computing technologies. You will also be able to compare the scalability and fault tolerance implications of using the selected methodologies.
Content: Advanced topics in cloud computing with emphasis on scalable distributed computing technologies employed in cloud computing. Key cloud technologies and their algorithmic background. Main topics are distributed file systems, distributed batch processing with the MapReduce and the Apache Spark computing frameworks, and distributed cloud based databases.
Assessment Methods and Criteria: Exam and home assignments. Course feedback.
Study Material: Lecture slides, tutorial assignments and their answers.
Substitutes for Courses: Replaces former courses CSE-E5430 / T-79.5308 Scalable Cloud Computing and T-79.5307 Distributed Computing.
Prerequisites: Basic programming skills (CS(E)-A1110 Programming 1). Familiarity with basic data structures (CS(E)-A1140 Data Structures and Algorithms or CS-E3190 / T-79.4202 Principles of Algorithmic Techniques) an asset.
Grading Scale: 0-5
Language of Instruction: English

CS-E4130 Computer Networks II - Advanced Features (5 cr)

Responsible teacher: Antti Ylä-Jääski
Level of the Course: Master's level
Teaching period: I - II (Autumn)
Workload: 24+0 (2+0); Lectures 24 h, Preparation for lectures 24 h, Homework assignments 27 h, Preparation for exam 57 h, Exam 3 h
Learning Outcomes: You will understand the current trends and challenges in computer networking. You are able to critically analyze the currently used networking technologies, such as modern transport protocols, mobile broadband wireless technologies, techniques to improve quality of experience, etc. You have insight into the trends and expected evolution of networking technologies. You will also learn to apply your theoretical knowledge through practical assignments.

Content: Advanced features of computer networks. The course offers a broad view of technologies mostly found “under the hood” of the Internet. Topics cover recently emerged technologies, such as modern wireless networks, data center networks, and software-defined networks as well as traditional ones, such as transport protocols and quality of service.
Assessment Methods and Criteria: Exam and homework assignments and course feedback.
Substitutes for Courses: Replaces former courses T-110.5111 / T-110.5116 Computer Networks II - Advanced Features.
Evaluation: 0-5
Language of Instruction: English

CS-E4130 Computer Networks II - Advanced Features (5 sp)

Ansvarig lärare: Antti Ylä-Jääski
Kursnivå: Master’s level
Undervisningsperiod: I - II (Autumn)
Arbetsmängd: 24+0 (2+0); Lectures 24 h, Preparation for lectures 24 h, Homework assignments 27 h, Preparation for exam 57 h, Exam 3 h
Lärandemål: You will understand the current trends and challenges in computer networking. You are able to critically analyze the currently used networking technologies, such as modern transport protocols, mobile broadband wireless technologies, techniques to improve quality of experience, etc. You have insight into the trends and expected evolution of networking technologies. You will also learn to apply your theoretical knowledge through practical assignments.
Innehåll: Advanced features of computer networks. The course offers a broad view of technologies mostly found “under the hood” of the Internet. Topics cover recently emerged technologies, such as modern wireless networks, data center networks, and software-defined networks as well as traditional ones, such as transport protocols and quality of service.
Metoder, arbetssätt och bedömningsgrunder: Exam and homework assignments and course feedback.
Ersättande prestationer: Replaces former courses T-110.5111 / T-110.5116 Computer Networks II - Advanced Features.
Bedömningsskala: 0-5
Undervisningsspråk: English

CS-E4130 Computer Networks II - Advanced Features (5 cr)

Responsible teacher: Antti Ylä-Jääski
Level of the Course: Master’s level
Teaching Period: I - II (Autumn)
Workload: 24+0 (2+0); Lectures 24 h, Preparation for lectures 24 h, Homework assignments 27 h, Preparation for exam 57 h, Exam 3 h
Learning Outcomes: You will understand the current trends and challenges in computer networking. You are able to critically analyze the currently used networking technologies, such as modern transport protocols, mobile broadband wireless technologies, techniques to improve quality of experience, etc. You have

insight into the trends and expected evolution of networking technologies. You will also learn to apply your theoretical knowledge through practical assignments.
Content: Advanced features of computer networks. The course offers a broad view of technologies mostly found "under the hood" of the Internet. Topics cover recently emerged technologies, such as modern wireless networks, data center networks, and software-defined networks as well as traditional ones, such as transport protocols and quality of service.
Assessment Methods and Criteria: Exam and homework assignments and course feedback.
Substitutes for Courses: Replaces former courses T-110.5111 / T-110.5116 Computer Networks II - Advanced Features.
Grading Scale: 0-5
Language of Instruction: English

CS-E4140 Applications and Services in Internet(V) (5 cr)

Responsible teacher: Antti Ylä-Jääski
Level of the Course: Master's level
Teaching period: I-II (Autumn)
Workload: 24+0 (2+0); Lectures 24 h, Preparation for lectures 24 h, Exercises 50 h (20 hours for the first exercise, 30 hours for the second exercise), Preparing for final exam 30 h, Final open exam 7 h
Learning Outcomes: You are familiar with common Internet application and service architectures, and are able to evaluate the extent of their applicability. You know how to study research literature, can summarize its results, and are capable of contributing your own analysis of a research topic.
Content: The course focuses on current issues concerning the design, development, deployment and management of applications and services in Internet. The topical areas vary yearly covering system architectures, service architectures, service management and related technical development issues. Some of the focal areas are peer-to-peer technologies, systems and services in comparison to more traditional client-server systems.
Assessment Methods and Criteria: Exam and exercises and course feedback.
Substitutes for Courses: Replaces former courses T-110.5150 / T-110.7100 Applications and Services in Internet.
Prerequisites: CSE-C2400 Computer Networks or equivalent skills.
Evaluation: 0-5
Language of Instruction: English
Further Information: The contents of the course vary.

CS-E4140 Applications and Services in Internet(V) (5 sp)

Ansvarig lärare: Antti Ylä-Jääski
Kursnivå: Master's level
Undervisningsperiod: I-II (Autumn)
Arbetsmängd: 24+0 (2+0); Lectures 24 h, Preparation for lectures 24 h, Exercises 50 h (20 hours for the first exercise, 30 hours for the second exercise), Preparing for final exam 30 h, Final open exam 7 h

Lärandemål: You are familiar with common Internet application and service architectures, and are able to evaluate the extent of their applicability. You know how to study research literature, can summarize its results, and are capable of contributing your own analysis of a research topic.
Innehåll: The course focuses on current issues concerning the design, development, deployment and management of applications and services in Internet. The topical areas vary yearly covering system architectures, service architectures, service management and related technical development issues. Some of the focal areas are peer-to-peer technologies, systems and services in comparison to more traditional client-server systems.
Metoder, arbetssätt och bedömningsgrunder: Exam and exercises and course feedback.
Ersättande prestationer: Replaces former courses T-110.5150 / T-110.7100 Applications and Services in Internet.
Förkunskaper: CSE-C2400 Computer Networks or equivalent skills.
Bedömningsskala: 0-5
Undervisningsspråk: English
Tilläggsinformation: The contents of the course vary.

CS-E4140 Applications and Services in Internet(V) (5 cr)

Responsible teacher: Antti Ylä-Jääski
Level of the Course: Master's level
Teaching Period: I-II (Autumn)
Workload: 24+0 (2+0); Lectures 24 h, Preparation for lectures 24 h, Exercises 50 h (20 hours for the first exercise, 30 hours for the second exercise), Preparing for final exam 30 h, Final open exam 7 h
Learning Outcomes: You are familiar with common Internet application and service architectures, and are able to evaluate the extent of their applicability. You know how to study research literature, can summarize its results, and are capable of contributing your own analysis of a research topic.
Content: The course focuses on current issues concerning the design, development, deployment and management of applications and services in Internet. The topical areas vary yearly covering system architectures, service architectures, service management and related technical development issues. Some of the focal areas are peer-to-peer technologies, systems and services in comparison to more traditional client-server systems.
Assessment Methods and Criteria: Exam and exercises and course feedback.
Substitutes for Courses: Replaces former courses T-110.5150 / T-110.7100 Applications and Services in Internet.
Prerequisites: CSE-C2400 Computer Networks or equivalent skills.
Grading Scale: 0-5
Language of Instruction: English
Further Information: The contents of the course vary.

CS-E4160 Laboratory Works in Networking and Security(V) (5-10 cr)

Responsible teacher: Tuomas Aura; Antti Ylä-Jääski

Level of the Course: Master's level
Teaching period: III-IV (Spring)
Workload: Lectures 2 h, assignments 131 h (for 5 cr)
Learning Outcomes: You have practical understanding and hands-on experience of networking and network-security technologies. You can build a computer network in practice and know the basic settings for an IP-based network. You are able to install and configure network services.
You can test and analyze network protocols and applications and interpret their workings based on the specifications. You know how to monitor and analyze network traffic and how to specify and install protection mechanisms including security protocols and traffic filters. The learning outcome may vary depending on the choice of assigments.
Content: The course consists of laboratory assignments related to designing and operating computer networks, telecommunications software and network services. Students will become familiar with common networking and security solutions and analysis tools. In this course, students apply principles learned in other courses.
Assessment Methods and Criteria: Participation in the first lecture, assignments and course feedback.
Study Material: Protocol specifications and software documentation.
Substitutes for Courses: Replaces former courses T-110.5102 Laboratory Works in Networking and Security, T-110.5101 Laboratory Works on Datacommunications Software and T-110.5201 Laboratory Works on Information Security.
Prerequisites: CSE-C2400 Computer Networks and CS-C3130 / CSE-C3400 Information Security or equivalent skills; basic Unix skills.
Evaluation: 0-5
Language of Instruction: English
Further Information: The contents of the course vary.

CS-E4160 Laboratory Works in Networking and Security(V) (5-10 sp)

Ansvarig lärare: Tuomas Aura; Antti Ylä-Jääski
Kursnivå: Master's level
Undervisningsperiod: III-IV (Spring)
Arbetsmängd: Lectures 2 h, assignments 131 h (for 5 cr)
Lärandemål: You have practical understanding and hands-on experience of networking and network-security technologies. You can build a computer network in practice and know the basic settings for an IP-based network. You are able to install and configure network services.
You can test and analyze network protocols and applications and interpret their workings based on the specifications. You know how to monitor and analyze network traffic and how to specify and install protection mechanisms including security protocols and traffic filters. The learning outcome may vary depending on the choice of assigments.
Innehåll: The course consists of laboratory assignments related to designing and operating computer networks, telecommunications software and network services.

Students will become familiar with common networking and security solutions and analysis tools. In this course, students apply principles learned in other courses.
Metoder, arbetssätt och bedömningsgrunder: Participation in the first lecture, assignments and course feedback.
Studiematerial: Protocol specifications and software documentation.
Ersättande prestationer: Replaces former courses T-110.5102 Laboratory Works in Networking and Security, T-110.5101 Laboratory Works on Datacommunications Software and T-110.5201 Laboratory Works on Information Security.
Förkunskaper: CSE-C2400 Computer Networks and CS-C3130 / CSE-C3400 Information Security or equivalent skills; basic Unix skills.
Bedömningsskala: 0-5
Undervisningsspråk: English
Tilläggsinformation: The contents of the course vary.

CS-E4160 Laboratory Works in Networking and Security(V) (5-10 cr)

Responsible teacher: Tuomas Aura; Antti Ylä-Jääski
Level of the Course: Master's level
Teaching Period: III-IV (Spring)
Workload: Lectures 2 h, assignments 131 h (for 5 cr)
Learning Outcomes: You have practical understanding and hands-on experience of networking and network-security technologies. You can build a computer network in practice and know the basic settings for an IP-based network. You are able to install and configure network services.
You can test and analyze network protocols and applications and interpret their workings based on the specifications. You know how to monitor and analyze network traffic and how to specify and install protection mechanisms including security protocols and traffic filters. The learning outcome may vary depending on the choice of assigments.
Content: The course consists of laboratory assignments related to designing and operating computer networks, telecommunications software and network services. Students will become familiar with common networking and security solutions and analysis tools. In this course, students apply principles learned in other courses.
Assessment Methods and Criteria: Participation in the first lecture, assignments and course feedback.
Study Material: Protocol specifications and software documentation.
Substitutes for Courses: Replaces former courses T-110.5102 Laboratory Works in Networking and Security, T-110.5101 Laboratory Works on Datacommunications Software and T-110.5201 Laboratory Works on Information Security.
Prerequisites: CSE-C2400 Computer Networks and CS-C3130 / CSE-C3400 Information Security or equivalent skills; basic Unix skills.
Grading Scale: 0-5
Language of Instruction: English

Further Information: The contents of the course vary.

CS-E4170 Mobile Systems Programming (5 cr)

Responsible teacher: Antti Ylä-Jääski
Level of the Course: Master's level
Teaching period: III - IV (Spring)
Workload: 16+0 (2+0), Lectures 16 h, Lecture preparation 16 h, Programming assignment 98 h
Learning Outcomes: You can write software for mobile devices. You know the central paradigms, practical solutions, and limitations for common mobile platforms.
Content: The course covers the general properties of mobile systems. In addition, you will familiarize yourself with the special features and most useful design patterns of mobile system programming. Special attention will be given to current environments.
Assessment Methods and Criteria: Project Assignments and course feedback.
Prerequisites: CSE-C2400 Computer Networks and CS-A1120 / ICS-A1120 Programming 2 or equivalent skills.
Evaluation: 0-5
Language of Instruction: English

CS-E4170 Mobile Systems Programming (5 sp)

Ansvarig lärare: Antti Ylä-Jääski
Kursnivå: Master's level
Undervisningsperiod: III - IV (Spring)
Arbetsmängd: 16+0 (2+0), Lectures 16 h, Lecture preparation 16 h, Programming assignment 98 h
Lärandemål: You can write software for mobile devices. You know the central paradigms, practical solutions, and limitations for common mobile platforms.
Innehåll: The course covers the general properties of mobile systems. In addition, you will familiarize yourself with the special features and most useful design patterns of mobile system programming. Special attention will be given to current environments.
Metoder, arbetssätt och bedömningsgrunder: Project Assignments and course feedback.
Förkunskaper: CSE-C2400 Computer Networks and CS-A1120 / ICS-A1120 Programming 2 or equivalent skills.
Bedömningsskala: 0-5
Undervisningsspråk: English

CS-E4170 Mobile Systems Programming (5 cr)

Responsible teacher: Antti Ylä-Jääski
Level of the Course: Master's level
Teaching Period: III - IV (Spring)
Workload: 16+0 (2+0), Lectures 16 h, Lecture preparation 16 h, Programming

assignment 98 h
Learning Outcomes: You can write software for mobile devices. You know the central paradigms, practical solutions, and limitations for common mobile platforms.
Content: The course covers the general properties of mobile systems. In addition, you will familiarize yourself with the special features and most useful design patterns of mobile system programming. Special attention will be given to current environments.
Assessment Methods and Criteria: Project Assignments and course feedback.
Prerequisites: CSE-C2400 Computer Networks and CS-A1120 / ICS-A1120 Programming 2 or equivalent skills.
Grading Scale: 0-5
Language of Instruction: English

CS-E4180 Internet Technologies for Mobile Computing(V) (2-10 cr)

Responsible teacher: Sasu Tarkoma
Level of the Course: Master's level
Teaching period: IV (Spring)
Learning Outcomes: You are familiar with the challenges and solutions of using Internet technologies in mobile computing. Overall understanding of the special solutions for mobile computing. Understanding of the commonly used architectural and design patterns.
Content: Variable-content course addressing advanced and current issues in the mobile computing domain. The topical areas vary yearly covering research questions in mobile technologies, mobile networking, applications and services in mobile networks, and standardisation forums for mobile computing.
Assessment Methods and Criteria: Seminar presentation and report. Active participation in the discussion of the interactive lectures. Course feedback.
Study Material: Sasu Tarkoma: Mobile Middleware, Wiley.
Prerequisites: CSE-C2400 Computer Networks or equivalent skills.
Evaluation: 0-5
Language of Instruction: English
Further Information: The course is intended for postgraduate students and for students, who have completed their Bachelor's degree. The contents of the course vary.

CS-E4180 Internet Technologies for Mobile Computing(V) (2-10 sp)

Ansvarig lärare: Sasu Tarkoma
Kursnivå: Master's level
Undervisningsperiod: IV (Spring)
Lärandemål: You are familiar with the challenges and solutions of using Internet technologies in mobile computing. Overall understanding of the special solutions for mobile computing. Understanding of the commonly used architectural and design patterns.
Innehåll: Variable-content course addressing advanced and current issues in the mobile computing domain. The topical areas vary yearly covering research

questions in mobile technologies, mobile networking, applications and services in mobile networks, and standardisation forums for mobile computing.
Metoder, arbetssätt och bedömningsgrunder: Seminar presentation and report. Active participation in the discussion of the interactive lectures. Course feedback.
Studiematerial: Sasu Tarkoma: Mobile Middleware, Wiley.
Förkunskaper: CSE-C2400 Computer Networks or equivalent skills.
Bedömningsskala: 0-5
Undervisningsspråk: English
Tilläggsinformation: The course is intended for postgraduate students and for students, who have completed their Bachelor's degree. The contents of the course vary.

CS-E4180 Internet Technologies for Mobile Computing(V) (2-10 cr)

Responsible teacher: Sasu Tarkoma
Level of the Course: Master's level
Teaching Period: IV (Spring)
Learning Outcomes: You are familiar with the challenges and solutions of using Internet technologies in mobile computing. Overall understanding of the special solutions for mobile computing. Understanding of the commonly used architectural and design patterns.
Content: Variable-content course addressing advanced and current issues in the mobile computing domain. The topical areas vary yearly covering research questions in mobile technologies, mobile networking, applications and services in mobile networks, and standardisation forums for mobile computing.
Assessment Methods and Criteria: Seminar presentation and report. Active participation in the discussion of the interactive lectures. Course feedback.
Study Material: Sasu Tarkoma: Mobile Middleware, Wiley.
Prerequisites: CSE-C2400 Computer Networks or equivalent skills.
Grading Scale: 0-5
Language of Instruction: English
Further Information: The course is intended for postgraduate students and for students, who have completed their Bachelor's degree. The contents of the course vary.

CS-E4200 Emergent User interfaces (5 cr)

Responsible teacher: David McGookin
Level of the Course: Master's level
Teaching period: III-IV (Spring 2016)
Learning Outcomes: After taking the course the student understands interaction techniques that deviate from the usual interfaces between human and computer, and has practical experience of building such an interaction.
Content: The course gives an overview of new and emerging UI paradigms that go beyond traditional WIMP interfaces. These include tangible interaction, multimodal interaction (audio, haptic, smell and taste) and the various sensors and sensing techniques and technologies used to implement them. A significant proportion of the course is spent on hands-on project work, where students will

collaborate to implement a novel user interface (most likely tangible) using electronic prototyping tools and software (most likely Arduino).
Assessment Methods and Criteria: Assessment is made on the report and demonstration of the group implementation project.
Study Material: To be announced later in course web page.
Substitutes for Courses: AS-75.2128/AS-75.128 Imaging and Display Technology, T-75.5100 Imaging and Display Technology, T-111.400, T-111.5400 Virtual Reality P, ME-E4200 / T-111.5900 Experimental User Interfaces.
Prerequisites: CS-E5220 / CSE-E5820 User Interface Construction
Evaluation: 0-5
Language of Instruction: English

CS-E4200 Emergent User interfaces (5 sp)

Ansvarig lärare: David McGookin
Kursnivå: Master's level
Undervisningsperiod: III-IV (Spring 2016)
Lärandemål: After taking the course the student understands interaction techniques that deviate from the usual interfaces between human and computer, and has practical experience of building such an interaction.
Innehåll: The course gives an overview of new and emerging UI paradigms that go beyond traditional WIMP interfaces. These include tangible interaction, multimodal interaction (audio, haptic, smell and taste) and the various sensors and sensing techniques and technologies used to implement them. A significant proportion of the course is spent on hands-on project work, where students will collaborate to implement a novel user interface (most likely tangible) using electronic prototyping tools and software (most likely Arduino).
Metoder, arbetssätt och bedömningsgrunder: Assessment is made on the report and demonstration of the group implementation project.
Studiematerial: To be announced later in course web page.
Ersättande prestationer: AS-75.2128/AS-75.128 Imaging and Display Technology, T-75.5100 Imaging and Display Technology, T-111.400, T-111.5400 Virtual Reality P, ME-E4200 / T-111.5900 Experimental User Interfaces.
Förkunskaper: CS-E5220 / CSE-E5820 User Interface Construction
Bedömningsskala: 0-5
Undervisningsspråk: English

CS-E4200 Emergent User interfaces (5 cr)

Responsible teacher: David McGookin
Level of the Course: Master's level
Teaching Period: III-IV (Spring 2016)
Learning Outcomes: After taking the course the student understands interaction techniques that deviate from the usual interfaces between human and computer, and has practical experience of building such an interaction.
Content: The course gives an overview of new and emerging UI paradigms that go beyond traditional WIMP interfaces. These include tangible interaction, multimodal interaction (audio, haptic, smell and taste) and the various sensors and

sensing techniques and technologies used to implement them. A significant proportion of the course is spent on hands-on project work, where students will collaborate to implement a novel user interface (most likely tangible) using electronic prototyping tools and software (most likely Arduino).
Assessment Methods and Criteria: Assessment is made on the report and demonstration of the group implementation project.
Study Material: To be announced later in course web page.
Substitutes for Courses: AS-75.2128/AS-75.128 Imaging and Display Technology, T-75.5100 Imaging and Display Technology, T-111.400, T-111.5400 Virtual Reality P, ME-E4200 / T-111.5900 Experimental User Interfaces.
Prerequisites: CS-E5220 / CSE-E5820 User Interface Construction
Grading Scale: 0-5
Language of Instruction: English

CS-E4210 Learning Technologies(V) (5 cr)

Responsible teacher: Lauri Malmi
Level of the Course: Master's level
Teaching period: I - II (Autumn)
Content: The course will discuss varying themes related to modern learning technologies, for example, functionalities and architectures of learning environments, automatic assessment techniques, social navigation in learning environments, intelligent tutoring systems, gamification, learning analytics, visualization techniques, and the role of modern learning theories in learning technology research. The theme and course requirements vary yearly.
Substitutes for Courses: CSE-E5280
Prerequisites: Bachelor's degree in computer science and engineering.
Evaluation: 0-5
Language of Instruction: English

CS-E4210 Learning Technologies(V) (5 sp)

Ansvarig lärare: Lauri Malmi
Kursnivå: Master's level
Undervisningsperiod: I - II (Autumn)
Innehåll: The course will discuss varying themes related to modern learning technologies, for example, functionalities and architectures of learning environments, automatic assessment techniques, social navigation in learning environments, intelligent tutoring systems, gamification, learning analytics, visualization techniques, and the role of modern learning theories in learning technology research. The theme and course requirements vary yearly.
Ersättande prestationer: CSE-E5280
Förkunskaper: Bachelor's degree in computer science and engineering.
Bedömningsskala: 0-5
Undervisningsspråk: English

CS-E4210 Learning Technologies(V) (5 cr)

Responsible teacher: Lauri Malmi
Level of the Course: Master's level
Teaching Period: I - II (Autumn)
Content: The course will discuss varying themes related to modern learning technologies, for example, functionalities and architectures of learning environments, automatic assessment techniques, social navigation in learning environments, intelligent tutoring systems, gamification, learning analytics, visualization techniques, and the role of modern learning theories in learning technology research. The theme and course requirements vary yearly.
Substitutes for Courses: CSE-E5280
Prerequisites: Bachelor's degree in computer science and engineering.
Grading Scale: 0-5
Language of Instruction: English

CS-E4220 Research methods(V) (5-8 cr)

Responsible teacher: Lauri Malmi
Level of the Course: Master's level
Teaching period: III - V (Spring)
Learning Outcomes: After you have taken this course you have the basic knowledge concerning the research process and different kinds of research methods, especially research methods that are used in educational research. You are able to evaluate the appropriateness of different research methods in relation to your own research question and to perform the study.
Content: Various research processes and methods that can be applied to study human actions, perceptions, and motivations in some form. Research methods that can be applied to study learning in the area of information technology are one central area of the course. Course content varies yearly.
Assessment Methods and Criteria: To be announced separately.
Substitutes for Courses: T-106.5550
Evaluation: 0-5, may be graded with pass/fail
Language of Instruction: English
Further Information: Course is intended mainly for PhD students who are planning or just starting their research. Graduate students who are planning their masters thesis may also benefit from this course.

CS-E4220 Research methods(V) (5-8 sp)

Ansvarig lärare: Lauri Malmi
Kursnivå: Master's level
Undervisningsperiod: III - V (Spring)
Lärandemål: After you have taken this course you have the basic knowledge concerning the research process and different kinds of research methods, especially research methods that are used in educational research. You are able to evaluate the appropriateness of different research methods in relation to your own research question and to perform the study.
Innehåll: Various research processes and methods that can be applied to study human actions, perceptions, and motivations in some form. Research methods that

can be applied to study learning in the area of information technology are one central area of the course. Course content varies yearly.
Metoder, arbetssätt och bedömningsgrunder: To be announced separately.
Ersättande prestationer: T-106.5550
Bedömningsskala: 0-5, may be graded with pass/fail
Undervisningsspråk: English
Tilläggsinformation: Course is intended mainly for PhD students who are planning or just starting their research. Graduate students who are planning their masters thesis may also benefit from this course.

CS-E4220 Research methods(V) (5-8 cr)

Responsible teacher: Lauri Malmi
Level of the Course: Master's level
Teaching Period: III - V (Spring)
Learning Outcomes: After you have taken this course you have the basic knowledge concerning the research process and different kinds of research methods, especially research methods that are used in educational research. You are able to evaluate the appropriateness of different research methods in relation to your own research question and to perform the study.
Content: Various research processes and methods that can be applied to study human actions, perceptions, and motivations in some form. Research methods that can be applied to study learning in the area of information technology are one central area of the course. Course content varies yearly.
Assessment Methods and Criteria: To be announced separately.
Substitutes for Courses: T-106.5550
Grading Scale: 0-5, may be graded with pass/fail
Language of Instruction: English
Further Information: Course is intended mainly for PhD students who are planning or just starting their research. Graduate students who are planning their masters thesis may also benefit from this course.

CS-E4230 Transaction Management in Databases (5 cr)

Responsible teacher: Eljas Soisalon-Soininen
Level of the Course: Master's level
Teaching period: IV (Spring)
Workload: Lectures 21 h, teaching in small groups 12 h.
Learning Outcomes: After following the course, the student will understand the significance and the goals of transaction management on both logical and physical levels. The student is taught how to take into account the implementation techniques used in transaction management when designing a database.
Content: Logical databases and database transactions. Log maintenance and buffer management. Rollback of transactions and database recovery. Transaction isolation and concurrency control, locking techniques. Recovery of physical database structures.
Assessment Methods and Criteria: Examination.
Study Material: Forthcoming book in English S. Sippu and E.

Soisalon-Soininen, Transaction Processing, Springer 2014 (availabe as a free eBook).
Substitutes for Courses: Replaces the course T-106.5221 /T-106.5220/T-106.5200.
Prerequisites: CS-A1150 / CSE-A1200 Databases and CS-A1140 / CSE-A1140 Data Structures and Algorithms or CS-A1141 /CSE-A1141 Data Structures and Algorithms Y.
Evaluation: 0-5
Language of Instruction: English

CS-E4230 Transaction Management in Databases (5 sp)

Ansvarig lärare: Eljas Soisalon-Soininen
Kursnivå: Master's level
Undervisningsperiod: IV (Spring)
Arbetsmängd: Lectures 21 h, teaching in small groups 12 h.
Lärandemål: After following the course, the student will understand the significance and the goals of transaction management on both logical and physical levels. The student is taught how to take into account the implementation techniques used in transaction management when designing a database.
Innehåll: Logical databases and database transactions. Log maintenance and buffer management. Rollback of transactions and database recovery. Transaction isolation and concurrency control, locking techniques. Recovery of physical database structures.
Metoder, arbetssätt och bedömningsgrunder: Examination.
Studiematerial: Forthcoming book in English S. Sippu and E. Soisalon-Soininen, Transaction Processing, Springer 2014 (availabe as a free eBook).
Ersättande prestationer: Replaces the course T-106.5221 /T-106.5220/T-106.5200.
Förkunskaper: CS-A1150 / CSE-A1200 Databases and CS-A1140 / CSE-A1140 Data Structures and Algorithms or CS-A1141 /CSE-A1141 Data Structures and Algorithms Y.
Bedömningsskala: 0-5
Undervisningsspråk: English

CS-E4230 Transaction Management in Databases (5 cr)

Responsible teacher: Eljas Soisalon-Soininen
Level of the Course: Master's level
Teaching Period: IV (Spring)
Workload: Lectures 21 h, teaching in small groups 12 h.
Learning Outcomes: After following the course, the student will understand the significance and the goals of transaction management on both logical and physical levels. The student is taught how to take into account the implementation techniques used in transaction management when designing a database.
Content: Logical databases and database transactions. Log maintenance and buffer management. Rollback of transactions and database recovery. Transaction isolation and concurrency control, locking techniques. Recovery of physical

database structures.
Assessment Methods and Criteria: Examination.
Study Material: Forthcoming book in English S. Sippu and E. Soisalon-Soininen, Transaction Processing, Springer 2014 (availabe as a free eBook).
Substitutes for Courses: Replaces the course T-106.5221 /T-106.5220/T-106.5200.
Prerequisites: CS-A1150 / CSE-A1200 Databases and CS-A1140 / CSE-A1140 Data Structures and Algorithms or CS-A1141 /CSE-A1141 Data Structures and Algorithms Y.
Grading Scale: 0-5
Language of Instruction: English

CS-E4240 Johdatus kääntäjätekniikkaan (5 op)

Vastuuopettaja: Jorma Tarhio
Kurssin taso: Kurssi on tarkoitettu perusopinnot suorittaneille.
Opetusperiodi: I - II
Työmäärä toteutustavoittain: Luento-opetus 24 h, harjoitustehtävien tekeminen 12 h, harjoitustyö 40 h.
Osaamistavoitteet: Kurssin suoritettuasi hallitset ohjelmointikielten kääntämisen periaatteet. Osaat tehdä kääntäjiä pienille sovellussuuntautuneille kielille kääntäjänlaatimisjärjestelmän avulla. Ymmärrät aikaisempaa enemmän ohjelmointikielten rakenteista.
Sisältö: Korkean tason kielten kääntäminen konekielelle. Selaaminen, jäsennys, syntaksiohjattu kääntäminen, tyyppitarkastukset, naiivi koodingenerointi. Harjoitustyössä tehdään toimivaa koodia tuottava kääntäjä pienelle kielelle.
Toteutus, työmuodot ja arvosteluperusteet: Tentti, laskuharjoituksia, harjoitustyö.
Oppimateriaali: Ilmoitetaan myöhemmin.
Esitiedot: CS-C2150 / ICS-C2000 Theoretical Computer Science tai vastaavat tiedot ja CS-A1120 / ICS-A1120 / T-106.1215 Ohjelmointi 2 tai CS-A1121 /CSE-A1121 /T-106.1240 Ohjelmoinnin peruskurssi Y2.
Arvosteluasteikko: 0-5
Opetuskieli: Suomi pääosin. Pyydettäessä suoritettavissa englanniksi.
Lisätietoja: Harjoitustyö suoritetaan periodilla II.

CS-E4240 Introduktion till kompilatorer (5 sp)

Ansvarig lärare: Jorma Tarhio
Kursnivå: Kursen är ämnad för studerande som avlagt grundstudierna.
Undervisningsperiod: I - II
Arbetsmängd: Föreläsningar 24 h, hemuppgifter 12 h, övningsarbete 40 h.
Lärandemål: Efter avklarad kurs behärskar du principerna för kompilering av programmeringsspråk. Du kan skapa en kompilator för små tillämpningsorienterade språk med användning av ett kompilatorskrivningssystem. Du förstår mer än tidigare om programmeringsspråkens strukturer.

Innehåll: Kompilering från högnivåspråk till maskinspråk. Lexikal analys, syntaxanalys, syntaxstyrd kompilering, typkontroll, naiv kodgenerering. Varje studerande konstruerar en kompilator som ett övningsarbete.
Metoder, arbetssätt och bedömningsgrunder: Tentamen, övningar, övningsarbete.
Studiematerial: Meddelas senare.
Förkunskaper: CS-C2150 / ICS-C2000 Theoretical Computer Science eller motsvarande kunskaper och CS-A1120 / ICS-A1120 / T-106.1215 Programmering 2 eller CS-A1121 /CSE-A1121 /T-106.1240 Grundkurs i programmering Y2.
Bedömningsskala: 0-5
Undervisningsspråk: Huvudsakligen på finska. Kan på begäran avläggas på engelska.
Tilläggsinformation: Övningsarbetet utförs under period II.

CS-E4240 Introduction to Compiling (5 cr)

Responsible teacher: Jorma Tarhio
Level of the Course: The course is only for students who have completed their general studies.
Teaching Period: I - II
Workload: Lectures 24 h, homework assignments 12 h, project 40 h.
Learning Outcomes: After the course you master the principles of compiling of programming languages. You can generate compilers for small application-oriented languages with a compiler writing system. You learn new details on principles of programming languages.
Content: Translation of high-level languages to machine code. Lexical analysis, syntax analysis, syntax-directed compilation, type checking, naive code generation. The student constructs a compiler producing executable code for a small language.
Assessment Methods and Criteria: Examination, exercises and programming assignment.
Study Material: To be announced later.
Prerequisites: CS-C2150 / ICS-C2000 Theoretical Computer Science or equivalent knowledge and CS-A1120 / ICS-A1120 / T-106.1215 Programming 2 or CS-A1121 /CSE-A1121 /T-106.1240 Basic course in programming Y2.
Grading Scale: 0-5
Language of Instruction: Primarily Finnish. The assessed work may be completed in English upon request.
Further Information: Lectures are in Finnish. Exercise problems are in English. The programming assignment is in Period II.

CS-E4300 Network Security (5 cr)

Responsible teacher: Tuomas Aura
Level of the Course: Master’s level
Teaching period: II
Workload: Lectures 24 h, Exercises 63 h, Independent study 30 h, Exam revision

and exam 16 h
Learning Outcomes: You will have a thorough understanding of common security technologies for computer networking and communications. You will be able to read protocol standards, apply and critically evaluate them in the development of secure systems, and develop basic security solutions for new applications. You will also know about the latest directions in network and communications security.
Content: Common security and privacy mechanisms and protocol standards for the Internet, intranet, wireless networks and mobile devices. Their design goals, failures and limitations. Security protocols for new technologies like contactless smart cards and ubiquitous computing devices. Hands-on exercises in secure systems design and analysis, and practice in reading specifications. Advanced and experimental network security and privacy solutions.
Assessment Methods and Criteria: Exam and exercises and course feedback.
Study Material: See course web page.
Substitutes for Courses: Replaces former course T-110.5241/T-110.5240 Network Security
Prerequisites: CSE-C2400 Computer Networks and CS-C3130 / CSE-C3400 Information Security or equivalent skills.
Evaluation: 0-5
Language of Instruction: English

CS-E4300 Network Security (5 sp)

Ansvarig lärare: Tuomas Aura
Kursnivå: Master's level
Undervisningsperiod: II
Arbetsmängd: Lectures 24 h, Exercises 63 h, Independent study 30 h, Exam revision and exam 16 h
Lärandemål: You will have a thorough understanding of common security technologies for computer networking and communications. You will be able to read protocol standards, apply and critically evaluate them in the development of secure systems, and develop basic security solutions for new applications. You will also know about the latest directions in network and communications security.
Innehåll: Common security and privacy mechanisms and protocol standards for the Internet, intranet, wireless networks and mobile devices. Their design goals, failures and limitations. Security protocols for new technologies like contactless smart cards and ubiquitous computing devices. Hands-on exercises in secure systems design and analysis, and practice in reading specifications. Advanced and experimental network security and privacy solutions.
Metoder, arbetssätt och bedömningsgrunder: Exam and exercises and course feedback.
Studiematerial: See course web page.
Ersättande prestationer: Replaces former course T-110.5241/T-110.5240 Network Security
Förkunskaper: CSE-C2400 Computer Networks and CS-C3130 / CSE-C3400

Information Security or equivalent skills.
Bedömningsskala: 0-5
Undervisningsspråk: English

CS-E4300 Network Security (5 cr)

Responsible teacher: Tuomas Aura
Level of the Course: Master's level
Teaching Period: II
Workload: Lectures 24 h, Exercises 63 h, Independent study 30 h, Exam revision and exam 16 h
Learning Outcomes: You will have a thorough understanding of common security technologies for computer networking and communications. You will be able to read protocol standards, apply and critically evaluate them in the development of secure systems, and develop basic security solutions for new applications. You will also know about the latest directions in network and communications security.
Content: Common security and privacy mechanisms and protocol standards for the Internet, intranet, wireless networks and mobile devices. Their design goals, failures and limitations. Security protocols for new technologies like contactless smart cards and ubiquitous computing devices. Hands-on exercises in secure systems design and analysis, and practice in reading specifications. Advanced and experimental network security and privacy solutions.
Assessment Methods and Criteria: Exam and exercises and course feedback.
Study Material: See course web page.
Substitutes for Courses: Replaces former course T-110.5241/T-110.5240 Network Security
Prerequisites: CSE-C2400 Computer Networks and CS-C3130 / CSE-C3400 Information Security or equivalent skills.
Grading Scale: 0-5
Language of Instruction: English

CS-E4310 Mobile Systems Security (5 cr)

Responsible teacher: N. Asokan
Status of the Course: Compulsory course of the Secure Systems track in the Computer Science and Engineering major.
Level of the Course: Master's level
Teaching period: III-IV
Workload: Lectures: 24 h (12 2h-contact sessions) Weekly written exercises: 51 h Programming project or paper: 40 h Independent study: 20 h
Learning Outcomes: You will learn the principles behind software and hardware system security architectures, with a particular focus on mobile devices. You will learn selected example platform security architectures in detail and be able to identify similarities and differences between different architectures. You will be able to recognize usability challenges in designing security mechanisms for mobile devices. You will gain an overview of current research issues in the area.
Content: Basics of access control, Android platform security architecture,

General model of platform security and design space for different instantiations, Trusted execution environments, Case studies of usable security challenges, Current research issues in system security. More information on course wiki at https://wiki.aalto.fi/display/mss
Assessment Methods and Criteria: Weekly written exercises, programming project or paper, course feedback.
Study Material: Supplementary reading - “Mobile Platform Security” by N.Asokan et al, Morgan & Claypool, December 2013
Prerequisites: CS-C3130 / CSE-C3400 Information Security or equivalent skills.
Evaluation: 0-5
Language of Instruction: English

CS-E4310 Mobile Systems Security (5 sp)

Ansvarig lärare: N. Asokan
Kursens status: Compulsory course of the Secure Systems track in the Computer Science and Engineering major.
Kursnivå: Master’s level
Undervisningsperiod: III-IV
Arbetsmängd: Lectures: 24 h (12 2h-contact sessions) Weekly written exercises: 51 h Programming project or paper: 40 h Independent study: 20 h
Lärandemål: You will learn the principles behind software and hardware system security architectures, with a particular focus on mobile devices. You will learn selected example platform security architectures in detail and be able to identify similarities and differences between different architectures. You will be able to recognize usability challenges in designing security mechanisms for mobile devices. You will gain an overview of current research issues in the area.
Innehåll: Basics of access control, Android platform security architecture, General model of platform security and design space for different instantiations, Trusted execution environments, Case studies of usable security challenges, Current research issues in system security. More information on course wiki at https://wiki.aalto.fi/display/mss
Metoder, arbetssätt och bedömningsgrunder: Weekly written exercises, programming project or paper, course feedback.
Studiematerial: Supplementary reading - “Mobile Platform Security” by N.Asokan et al, Morgan & Claypool, December 2013
Förkunskaper: CS-C3130 / CSE-C3400 Information Security or equivalent skills.
Bedömningsskala: 0-5
Undervisningsspråk: English

CS-E4310 Mobile Systems Security (5 cr)

Responsible teacher: N. Asokan
Status of the Course: Compulsory course of the Secure Systems track in the Computer Science and Engineering major.
Level of the Course: Master’s level
Teaching Period: III-IV

Workload: Lectures: 24 h (12 2h-contact sessions) Weekly written exercises: 51 h Programming project or paper: 40 h Independent study: 20 h
Learning Outcomes: You will learn the principles behind software and hardware system security architectures, with a particular focus on mobile devices. You will learn selected example platform security architectures in detail and be able to identify similarities and differences between different architectures. You will be able to recognize usability challenges in designing security mechanisms for mobile devices. You will gain an overview of current research issues in the area.
Content: Basics of access control, Android platform security architecture, General model of platform security and design space for different instantiations, Trusted execution environments, Case studies of usable security challenges, Current research issues in system security. More information on course wiki at https://wiki.aalto.fi/display/mss
Assessment Methods and Criteria: Weekly written exercises, programming project or paper, course feedback.
Study Material: Supplementary reading - "Mobile Platform Security" by N.Asokan et al, Morgan & Claypool, December 2013
Prerequisites: CS-C3130 / CSE-C3400 Information Security or equivalent skills.
Grading Scale: 0-5
Language of Instruction: English

CS-E4320 Cryptography and Data Security (5 cr)

Responsible teacher: Tuomas Aura
Level of the Course: The course is only for students who have completed their general studies.
Teaching period: I - II (Autumn)
Workload:
Lectures: 24 (4)
Teaching in small groups: 12 (2)
Programming assignments: 36
Other independent work: 58
Exam: 3
Learning Outcomes: Having completed the course, you are able to recognise commonly used mathematical building blocks in cryptographic primitives and understand how they work. You are also familiar with the basic principles of cryptographic security which are authentication, confidentiality, and integrity of data. You can describe common attacks such as meet-in-the-middle, man-in-the-middle, and collision attacks, and understand basic limits of cryptographic security defined in terms of parameter lengths. Given a cryptographic primitive in a data security system, you can explain why such a primitive is used and what kind of security task it performs, as well as how it relates to other primitives in the system.
Content: Data and communications security. Principles of cryptographic security. Secure and efficient cryptosystem implementation techniques. Symmetric key cryptosystems. Stream ciphers. Block ciphers. Modes of operation. Hash functions. Asymmetric cryptosystems. Digital signatures. Data authentication.

Entity authentication and key agreement. Applications of cryptography in systems such as SSL, TLS, IPSec, GSM, Bluetooth.
Assessment Methods and Criteria: Exam and three programming tasks.
Study Material: W. Stallings: Cryptography and Network Security: Principles and Practices, 3rd or 4th edition, Prentice Hall.
Substitutes for Courses: Replaces former course T-79.4502 / T-79.4501 Cryptography and Data Security.
Prerequisites: No formal prerequisites. Recommended: Basics of discrete mathematics, elementary programming skills, algorithm complexity.
Evaluation: 0-5
Language of Instruction: English.

CS-E4320 Cryptography and Data Security (5 sp)

Ansvarig lärare: Tuomas Aura
Kursnivå: The course is only for students who have completed their general studies.
Undervisningsperiod: I - II (Autumn)
Arbetsmängd:
Lectures: 24 (4)
Teaching in small groups: 12 (2)
Programming assignments: 36
Other independent work: 58
Exam: 3
Lärandemål: Having completed the course, you are able to recognise commonly used mathematical building blocks in cryptographic primitives and understand how they work. You are also familiar with the basic principles of cryptographic security which are authentication, confidentiality, and integrity of data. You can describe common attacks such as meet-in-the-middle, man-in-the-middle, and collision attacks, and understand basic limits of cryptographic security defined in terms of parameter lengths. Given a cryptographic primitive in a data security system, you can explain why such a primitive is used and what kind of security task it performs, as well as how it relates to other primitives in the system.
Innehåll: Data and communications security. Principles of cryptographic security. Secure and efficient cryptosystem implementation techniques. Symmetric key cryptosystems. Stream ciphers. Block ciphers. Modes of operation. Hash functions. Asymmetric cryptosystems. Digital signatures. Data authentication. Entity authentication and key agreement. Applications of cryptography in systems such as SSL, TLS, IPSec, GSM, Bluetooth.
Metoder, arbetssätt och bedömningsgrunder: Exam and three programming tasks.
Studiematerial: W. Stallings: Cryptography and Network Security: Principles and Practices, 3rd or 4th edition, Prentice Hall.
Ersättande prestationer: Replaces former course T-79.4502 / T-79.4501 Cryptography and Data Security.
Förkunskaper: No formal prerequisites. Recommended: Basics of discrete mathematics, elementary programming skills, algorithm complexity.

Bedömningsskala: 0-5
Undervisningsspråk: English.

CS-E4320 Cryptography and Data Security (5 cr)

Responsible teacher: Tuomas Aura
Level of the Course: The course is only for students who have completed their general studies.
Teaching Period: I - II (Autumn)
Workload:
Lectures: 24 (4)
Teaching in small groups: 12 (2)
Programming assignments: 36
Other independent work: 58
Exam: 3
Learning Outcomes: Having completed the course, you are able to recognise commonly used mathematical building blocks in cryptographic primitives and understand how they work. You are also familiar with the basic principles of cryptographic security which are authentication, confidentiality, and integrity of data. You can describe common attacks such as meet-in-the-middle, man-in-the-middle, and collision attacks, and understand basic limits of cryptographic security defined in terms of parameter lengths. Given a cryptographic primitive in a data security system, you can explain why such a primitive is used and what kind of security task it performs, as well as how it relates to other primitives in the system.
Content: Data and communications security. Principles of cryptographic security. Secure and efficient cryptosystem implementation techniques. Symmetric key cryptosystems. Stream ciphers. Block ciphers. Modes of operation. Hash functions. Asymmetric cryptosystems. Digital signatures. Data authentication. Entity authentication and key agreement. Applications of cryptography in systems such as SSL, TLS, IPSec, GSM, Bluetooth.
Assessment Methods and Criteria: Exam and three programming tasks.
Study Material: W. Stallings: Cryptography and Network Security: Principles and Practices, 3rd or 4th edition, Prentice Hall.
Substitutes for Courses: Replaces former course T-79.4502 / T-79.4501 Cryptography and Data Security.
Prerequisites: No formal prerequisites. Recommended: Basics of discrete mathematics, elementary programming skills, algorithm complexity.
Grading Scale: 0-5
Language of Instruction: English.

CS-E4400 Design of WWW Services (5 cr)

Responsible teacher: Petri Vuorimaa
Status of the Course: Compulsory course of the Web Technologies, Applications, and Science track in Computer Science major.
Level of the Course: Master’s level
Teaching period: I – II (Autumn 2016)

Workload: Lectures 24 h (2 x 2 h/week, 12 times), group work 84 h (= 108 h in total).
Learning Outcomes: During the course, you will go through the whole process of creating a finalized WWW service ready to be used by external users. You will gain an understanding of important aspects of WWW development, including service design (user categorization, functional design, information architecture, information security, graphic design, usability, etc.), service implementation (markup languages, Web programming languages and frameworks, databases, etc.), and content development (content production, copyrights, etc.). You will practice your skills while planning and implementing your service and documenting service development process in a sizable project work exercise. After the course, you will be able to develop a WWW service.
Content: The course deals with designing and implementing WWW sites and interactive services on the Web. Guest lecturers from academia and industry cover relevant aspects, such as various Web service implementation techniques, usability, web service life span, graphic design, usability, and information security. The project work done in groups consists of designing and implementing a WWW service and documenting the development process.
Assessment Methods and Criteria: The course teaching consists of lectures and project work done in groups. The grading is 100% based on the project work, which consists of three phases: design phase, demo phase, and final phase. Students receive points after each phase; final grade is given based on the total number of points.
Study Material: Lecture slides and assignment instructions as well as the material listed on the course web pages (see Additional reading).
Substitutes for Courses: Replaces courses ME-E4360 Design of WWW Services, T-111.361, T-111.362, T-111.4360.
Prerequisites: CS-C1180/ME-C2300 Basics of web publishing / T-75.1110 XML Based Description Languages / T-111.1100 Tools of Digital Media recommended.
Evaluation: 0-5
Registration for Courses: Registration via WebOodi. Check the registration times on WebOodi.
Language of Instruction: English
Further Information: All lectures are held during period I.

CS-E4400 Design of WWW Services (5 sp)

Ansvarig lärare: Petri Vuorimaa
Kursens status: Compulsory course of the Web Technologies, Applications, and Science track in Computer Science major.
Kursnivå: Master's level
Undervisningsperiod: I – II (Autumn 2016)
Arbetsmängd: Lectures 24 h (2 x 2 h/week, 12 times), group work 84 h (= 108 h in total).
Lärandemål: During the course, you will go through the whole process of creating a finalized WWW service ready to be used by external users. You will gain an understanding of important aspects of WWW development, including

service design (user categorization, functional design, information architecture, information security, graphic design, usability, etc.), service implementation (markup languages, Web programming languages and frameworks, databases, etc.), and content development (content production, copyrights, etc.). You will practice your skills while planning and implementing your service and documenting service development process in a sizable project work exercise. After the course, you will be able to develop a WWW service.
Innehåll: The course deals with designing and implementing WWW sites and interactive services on the Web. Guest lecturers from academia and industry cover relevant aspects, such as various Web service implementation techniques, usability, web service life span, graphic design, usability, and information security. The project work done in groups consists of designing and implementing a WWW service and documenting the development process.
Metoder, arbetssätt och bedömningsgrunder: The course teaching consists of lectures and project work done in groups. The grading is 100% based on the project work, which consists of three phases: design phase, demo phase, and final phase. Students receive points after each phase; final grade is given based on the total number of points.
Studiematerial: Lecture slides and assignment instructions as well as the material listed on the course web pages (see Additional reading).
Ersättande prestationer: Replaces courses ME-E4360 Design of WWW Services, T-111.361, T-111.362, T-111.4360.
Förkunskaper: CS-C1180/ME-C2300 Basics of web publishing / T-75.1110 XML Based Description Languages / T-111.1100 Tools of Digital Media recommended.
Bedömningsskala: 0-5
Anmälning: Registration via WebOodi. Check the registration times on WebOodi.
Undervisningsspråk: English
Tilläggsinformation: All lectures are held during period I.

CS-E4400 Design of WWW Services (5 cr)

Responsible teacher: Petri Vuorimaa
Status of the Course: Compulsory course of the Web Technologies, Applications, and Science track in Computer Science major.
Level of the Course: Master's level
Teaching Period: I – II (Autumn 2016)
Workload: Lectures 24 h (2 x 2 h/week, 12 times), group work 84 h (= 108 h in total).
Learning Outcomes: During the course, you will go through the whole process of creating a finalized WWW service ready to be used by external users. You will gain an understanding of important aspects of WWW development, including service design (user categorization, functional design, information architecture, information security, graphic design, usability, etc.), service implementation (markup languages, Web programming languages and frameworks, databases, etc.), and content development (content production, copyrights, etc.). You will

practice your skills while planning and implementing your service and documenting service development process in a sizable project work exercise. After the course, you will be able to develop a WWW service.
Content: The course deals with designing and implementing WWW sites and interactive services on the Web. Guest lecturers from academia and industry cover relevant aspects, such as various Web service implementation techniques, usability, web service life span, graphic design, usability, and information security. The project work done in groups consists of designing and implementing a WWW service and documenting the development process.
Assessment Methods and Criteria: The course teaching consists of lectures and project work done in groups. The grading is 100% based on the project work, which consists of three phases: design phase, demo phase, and final phase. Students receive points after each phase; final grade is given based on the total number of points.
Study Material: Lecture slides and assignment instructions as well as the material listed on the course web pages (see Additional reading).
Substitutes for Courses: Replaces courses ME-E4360 Design of WWW Services, T-111.361, T-111.362, T-111.4360.
Prerequisites: CS-C1180/ME-C2300 Basics of web publishing / T-75.1110 XML Based Description Languages / T-111.1100 Tools of Digital Media recommended.
Grading Scale: 0-5
Registration for Courses: Registration via WebOodi. Check the registration times on WebOodi.
Language of Instruction: English
Further Information: All lectures are held during period I.

CS-E4410 Semantic Web (5 cr)

Responsible teacher: Eero Hyvönen
Level of the Course: Master's level
Teaching period: III – V (Spring 2016)
Workload: 16 + 16 (2 +2), lectures and literature 45%, exercises and programming 55%.
Learning Outcomes: The idea of the course is to get to know the idea of semantic web, the technologies and its possible applications and learn how to use the programming tools of the area in practice.
Content: The core content of the course consists of Semantic Web technologies and standards such as Resource Description Framework (RDF) and Web Ontology Language (OWL). Rule systems, ontology techniques and Semantic Web tools and applications will also be covered. The theoretical part of the course will be complemented by exercise work.
Assessment Methods and Criteria: Examination (100%) and exercises.
Study Material: G. Antoniou, F. van Harmelen, A Semantic Web Primer. MIT Press, 2008. Lecture slides and other material.
Substitutes for Courses: ME-E4300 / AS-75.2500, AS-75.105, T-75.4300.
Prerequisites: Data Structures and Algorithms (recommendation).
Evaluation: 0-5

Language of Instruction: English

CS-E4410 Semantic Web (5 sp)

Ansvarig lärare: Eero Hyvönen
Kursnivå: Master's level
Undervisningsperiod: III – V (Spring 2016)
Arbetsmängd: 16 + 16 (2 +2), lectures and literature 45%, exercises and programming 55%.
Lärandemål: The idea of the course is to get to know the idea of semantic web, the technologies and its possible applications and learn how to use the programming tools of the area in practice.
Innehåll: The core content of the course consists of Semantic Web technologies and standards such as Resource Description Framework (RDF) and Web Ontology Language (OWL). Rule systems, ontology techniques and Semantic Web tools and applications will also be covered. The theoretical part of the course will be complemented by exercise work.
Metoder, arbetssätt och bedömningsgrunder: Examination (100%) and exercises.
Studiematerial: G. Antoniou, F. van Harmelen, A Semantic Web Primer. MIT Press, 2008. Lecture slides and other material.
Ersättande prestationer: ME-E4300 / AS-75.2500, AS-75.105, T-75.4300.
Förkunskaper: Data Structures and Algorithms (recommendation).
Bedömningsskala: 0-5
Undervisningsspråk: English

CS-E4410 Semantic Web (5 cr)

Responsible teacher: Eero Hyvönen
Level of the Course: Master's level
Teaching Period: III – V (Spring 2016)
Workload: 16 + 16 (2 +2), lectures and literature 45%, exercises and programming 55%.
Learning Outcomes: The idea of the course is to get to know the idea of semantic web, the technologies and its possible applications and learn how to use the programming tools of the area in practice.
Content: The core content of the course consists of Semantic Web technologies and standards such as Resource Description Framework (RDF) and Web Ontology Language (OWL). Rule systems, ontology techniques and Semantic Web tools and applications will also be covered. The theoretical part of the course will be complemented by exercise work.
Assessment Methods and Criteria: Examination (100%) and exercises.
Study Material: G. Antoniou, F. van Harmelen, A Semantic Web Primer. MIT Press, 2008. Lecture slides and other material.
Substitutes for Courses: ME-E4300 / AS-75.2500, AS-75.105, T-75.4300.
Prerequisites: Data Structures and Algorithms (recommendation).
Grading Scale: 0-5
Language of Instruction: English

CS-E4420 Information Retrieval (5 cr)

Responsible teacher: Eero Hyvönen
Level of the Course: Master's level
Teaching period: III – IV (Spring 2016)
Workload: Lectures 24 h, exercises 42 h, self-study 36 h.
Learning Outcomes: Upon completion of the course the student knows the basic concepts and methods of information retrieval.
Content: Classic information retrieval (Boolean method, vector space model, probability models), content based retrieval (images, multimedia), web retrieval systems, evaluation of information retrieval systems.
Assessment Methods and Criteria: Exam and exercises.
Study Material: Christopher D. Manning, Prabhakar Raghavan and Hinrich Schütze, Introduction to Information Retrieval, Cambridge University Press. 2008. Additional material to be announced later.
Substitutes for Courses: Replaces course ME-E4400 / T-75.4400 Information Retrieval.
Evaluation: 0-5
Language of Instruction: English

CS-E4420 Information Retrieval (5 sp)

Ansvarig lärare: Eero Hyvönen
Kursnivå: Master's level
Undervisningsperiod: III – IV (Spring 2016)
Arbetsmängd: Lectures 24 h, exercises 42 h, self-study 36 h.
Lärandemål: Upon completion of the course the student knows the basic concepts and methods of information retrieval.
Innehåll: Classic information retrieval (Boolean method, vector space model, probability models), content based retrieval (images, multimedia), web retrieval systems, evaluation of information retrieval systems.
Metoder, arbetssätt och bedömningsgrunder: Exam and exercises.
Studiematerial: Christopher D. Manning, Prabhakar Raghavan and Hinrich Schütze, Introduction to Information Retrieval, Cambridge University Press. 2008. Additional material to be announced later.
Ersättande prestationer: Replaces course ME-E4400 / T-75.4400 Information Retrieval.
Bedömningsskala: 0-5
Undervisningsspråk: English

CS-E4420 Information Retrieval (5 cr)

Responsible teacher: Eero Hyvönen
Level of the Course: Master's level
Teaching Period: III – IV (Spring 2016)
Workload: Lectures 24 h, exercises 42 h, self-study 36 h.
Learning Outcomes: Upon completion of the course the student knows the basic

concepts and methods of information retrieval.
Content: Classic information retrieval (Boolean method, vector space model, probability models), content based retrieval (images, multimedia), web retrieval systems, evaluation of information retrieval systems.
Assessment Methods and Criteria: Exam and exercises.
Study Material: Christopher D. Manning, Prabhakar Raghavan and Hinrich Schütze, Introduction to Information Retrieval, Cambridge University Press. 2008. Additional material to be announced later.
Substitutes for Courses: Replaces course ME-E4400 / T-75.4400 Information Retrieval.
Grading Scale: 0-5
Language of Instruction: English

CS-E4430 Web Services (4 cr)

Responsible teacher: Eetu Mäkelä; Eero Hyvönen
Level of the Course: The course is only for students who have completed their Bachelor's Degree.
Teaching period: I - II (Autumn)
Workload: Lectures 20 h, assignments 30h, study circles 20 h and home examination 30 h.
Learning Outcomes: Having completed the course the student will be able to analyse web-service techniques and their relations to service requirements. The student will be able to apply web-service techniques to service scenarios and analyse techniques required in distributed environments, such as transaction management and synchronisation of messaging.
Content: The course covers web-services standards, tools and models such as SOAP, WSDL, UDDI and REST, choreography languages, semantic markup languages such as WSMF and relevant tools and applications.
Assessment Methods and Criteria: Home examination (100%). Assignment and study circles on grading scale pass/fail.
Study Material: Course book: Alonso, G., Casati, F., Kuno, H., Machiraju, V.: Web Services: Concepts, Architectures and Applications. Springer-Verlag, Berlin, Heidelberg. 2004. ISBN:
3-540-44008-9. Chapters 3 and 4 will be excluded (exception chapter 3.3). In addition articles and further material.
Substitutes for Courses: T-75.5300 and AS-75.3601/AS-75.3600
Prerequisites: T-75.1110/AS-75.1110/AS-0.1110/AS-0.110, ME-E4300 / T-75.4300 Semantic Web (recommended).
Evaluation: 0-5
Language of Instruction: English

CS-E4430 Web Services (4 sp)

Ansvarig lärare: Eetu Mäkelä; Eero Hyvönen
Kursnivå: The course is only for students who have completed their Bachelor's Degree.
Undervisningsperiod: I - II (Autumn)

Arbetsmängd: Lectures 20 h, assignments 30h, study circles 20 h and home examination 30 h.
Lärandemål: Having completed the course the student will be able to analyse web-service techniques and their relations to service requirements. The student will be able to apply web-service techniques to service scenarios and analyse techniques required in distributed environments, such as transaction management and synchronisation of messaging.
Innehåll: The course covers web-services standards, tools and models such as SOAP, WSDL, UDDI and REST, choreography languages, semantic markup languages such as WSMF and relevant tools and applications.
Metoder, arbetssätt och bedömningsgrunder: Home examination (100%). Assignment and study circles on grading scale pass/fail.
Studiematerial: Course book: Alonso, G., Casati, F., Kuno, H., Machiraju, V.: Web Services: Concepts, Architectures and Applications. Springer-Verlag, Berlin, Heidelberg. 2004. ISBN:
3-540-44008-9. Chapters 3 and 4 will be excluded (exception chapter 3.3). In addition articles and further material.
Ersättande prestationer: T-75.5300 and AS-75.3601/AS-75.3600
Förkunskaper: T-75.1110/AS-75.1110/AS-0.1110/AS-0.110, ME-E4300 / T-75.4300 Semantic Web (recommended).
Bedömningsskala: 0-5
Undervisningsspråk: English

CS-E4430 Web Services (4 cr)

Responsible teacher: Eetu Mäkelä; Eero Hyvönen
Level of the Course: The course is only for students who have completed their Bachelor's Degree.
Teaching Period: I - II (Autumn)
Workload: Lectures 20 h, assignments 30h, study circles 20 h and home examination 30 h.
Learning Outcomes: Having completed the course the student will be able to analyse web-service techniques and their relations to service requirements. The student will be able to apply web-service techniques to service scenarios and analyse techniques required in distributed environments, such as transaction management and synchronisation of messaging.
Content: The course covers web-services standards, tools and models such as SOAP, WSDL, UDDI and REST, choreography languages, semantic markup languages such as WSMF and relevant tools and applications.
Assessment Methods and Criteria: Home examination (100%). Assignment and study circles on grading scale pass/fail.
Study Material: Course book: Alonso, G., Casati, F., Kuno, H., Machiraju, V.: Web Services: Concepts, Architectures and Applications. Springer-Verlag, Berlin, Heidelberg. 2004. ISBN:
3-540-44008-9. Chapters 3 and 4 will be excluded (exception chapter 3.3). In addition articles and further material.
Substitutes for Courses: T-75.5300 and AS-75.3601/AS-75.3600

Prerequisites: T-75.1110/AS-75.1110/AS-0.1110/AS-0.110, ME-E4300 / T-75.4300 Semantic Web (recommended).
Grading Scale: 0-5
Language of Instruction: English

CS-E4440 WWW Applications (4 cr)

Responsible teacher: Petri Vuorimaa
Level of the Course: Master or doctoral level.
Teaching period: I - II (Autumn 2016)
Workload: Lectures and workshop 28 h, group work 80 h (= 108 h in total).
Learning Outcomes: Students will learn how to search scientific/technical information and effectively communicate their findings to the public in the form of a written report and a short presentation. In addition, they will learn how to work as part of a group that plans, schedules, executes, and documents a small web development project.
Content: The course deals with emerging/experimental web technologies. The actual topics addressed vary from year to year. In previous years, both the presentation and project work are combined together as a single project, which is done in groups of two students. The topics include most important HTML5 technologies, such as Canvas, WebGL, WebSockets, Web Workers, Geolocation, local storage, and CORS.
Assessment Methods and Criteria: The course grade is based on the final report and oral presentation of the project work.
Study Material: Lecture slides and assignment instructions as well as the material listed on the course web pages (see Additional reading).
Prerequisites: CS-C3170 / CSE-C3210 Web Software Development, CS-E4400 / ME-E4360 Design of WWW Services or equivalent knowledge of web application development.
Evaluation: 0-5
Registration for Courses: Registration via WebOodi. Check the registration times on WebOodi.
Language of Instruction: English
Further Information: The number of participants is limited to 20. Students have to confirm their participation by attending the first lecture.

CS-E4440 WWW Applications (4 sp)

Ansvarig lärare: Petri Vuorimaa
Kursnivå: Master or doctoral level.
Undervisningsperiod: I - II (Autumn 2016)
Arbetsmängd: Lectures and workshop 28 h, group work 80 h (= 108 h in total).
Lärandemål: Students will learn how to search scientific/technical information and effectively communicate their findings to the public in the form of a written report and a short presentation. In addition, they will learn how to work as part of a group that plans, schedules, executes, and documents a small web development project.
Innehåll: The course deals with emerging/experimental web technologies. The

actual topics addressed vary from year to year. In previous years, both the presentation and project work are combined together as a single project, which is done in groups of two students. The topics include most important HTML5 technologies, such as Canvas, WebGL, WebSockets, Web Workers, Geolocation, local storage, and CORS.
Metoder, arbetssätt och bedömningsgrunder: The course grade is based on the final report and oral presentation of the project work.
Studiematerial: Lecture slides and assignment instructions as well as the material listed on the course web pages (see Additional reading).
Förkunskaper: CS-C3170 / CSE-C3210 Web Software Development, CS-E4400 / ME-E4360 Design of WWW Services or equivalent knowledge of web application development.
Bedömningsskala: 0-5
Anmälning: Registration via WebOodi. Check the registration times on WebOodi.
Undervisningsspråk: English
Tilläggsinformation: The number of participants is limited to 20. Students have to confirm their participation by attending the first lecture.

CS-E4440 WWW Applications (4 cr)

Responsible teacher: Petri Vuorimaa
Level of the Course: Master or doctoral level.
Teaching Period: I - II (Autumn 2016)
Workload: Lectures and workshop 28 h, group work 80 h (= 108 h in total).
Learning Outcomes: Students will learn how to search scientific/technical information and effectively communicate their findings to the public in the form of a written report and a short presentation. In addition, they will learn how to work as part of a group that plans, schedules, executes, and documents a small web development project.
Content: The course deals with emerging/experimental web technologies. The actual topics addressed vary from year to year. In previous years, both the presentation and project work are combined together as a single project, which is done in groups of two students. The topics include most important HTML5 technologies, such as Canvas, WebGL, WebSockets, Web Workers, Geolocation, local storage, and CORS.
Assessment Methods and Criteria: The course grade is based on the final report and oral presentation of the project work.
Study Material: Lecture slides and assignment instructions as well as the material listed on the course web pages (see Additional reading).
Prerequisites: CS-C3170 / CSE-C3210 Web Software Development, CS-E4400 / ME-E4360 Design of WWW Services or equivalent knowledge of web application development.
Grading Scale: 0-5
Registration for Courses: Registration via WebOodi. Check the registration times on WebOodi.
Language of Instruction: English

Further Information: The number of participants is limited to 20. Students have to confirm their participation by attending the first lecture.

CS-E4450 Explorative Information Visualization (5 cr)

Responsible teacher: Tapio Takala; Tomi Kauppinen
Level of the Course: Master's level
Teaching period: I – II (Autumn)
Learning Outcomes:
Learning Outcomes in three categories (must know, should know, nice to know):
Must know: Basics about how to visualize information in interactive and explorative ways.
For this the students will learn how to support information usability for creating visualizations with web technologies. Course is motivated by showing real examples of dealing with spatial,temporal and thematic information, and solutions to them. Those are required to be well understood as a result of the course.
Should Know: Handling spatial, temporal and thematic data in creative ways. Understanding how to query only the part of data that is useful in a given aggregation, visualization or browsing function is an example of this. Included are different explorative visualization strategies, and understanding of space and time as major integrators for data. As part of this, students should know the requirements for data, and data descriptions for various visualization and application scenarios.
Nice to know: The works of other students in more detail, i.e. topics, research problems, provided methods and solutions presented in them are material in the course, and belong to this category. Students are introduced to other topics via discussion sessions, presentations, and via the peer review process where students are required to give feedback to other works.
In summary students will learn theory, techniques, presentation and organizational skills for creating explorative information visualizations.
Content: In this course we study approaches for explorative information visualization. The idea is to support information usability by enabling to explore interesting patterns from datasets in visual ways. Explorative information visualization makes a joint use of efficient metaphors like hierarchies, graphs, charts, lists, maps, and timelines. The course supports students to understand the role of hybrid methods from spatial data mining to network analytics, and from linked data to time-series handling for supporting information visualization. Our focus is on the process-thinking, thus starting from sparse datasets and to understand the tasks for iteratively making sense of data. In the course we will have a special emphasis on visualizing spatial and temporal information jointly with thematic information. The seminar builds on the idea of flipped classroom and blended learning ideas, and thus combines online learning materials with intensive face to face sessions. Online materials consist of lectures for preparing, handling and analyzing data, integrating different datasets, and for approaches to create visual demonstrations of data with maps, timelines and thematic overviews. The course consists of sessions each having a brief lecture, discussions, group works and presentations. The theoretical part of the course is

deepened via our joint sessions and by individual seminar reports on selected topics.
Assessment Methods and Criteria: Grading of the seminar is as follows: 1/3 for the seminar work, 1/3 for the opponent work, 1/3 for the active participation and presentation of the seminar work. As part of the active participation grade, students are required to prepare a one page abstract of the assigned readings / lectures in relation to her own topic.
Study Material: Online videos, tutorials and exercises, face to face sessions, articles.
Evaluation: 0-5
Registration for Courses: Registration via WebOodi. Check the registration times on WebOodi.
Language of Instruction: English (default) or Finnish depending on implementation.

CS-E4450 Explorative Information Visualization (5 sp)

Ansvarig lärare: Tapio Takala; Tomi Kauppinen
Kursnivå: Master's level
Undervisningsperiod: I – II (Autumn)
Lärandemål:
Learning Outcomes in three categories (must know, should know, nice to know):
Must know: Basics about how to visualize information in interactive and explorative ways.
For this the students will learn how to support information usability for creating visualizations with web technologies. Course is motivated by showing real examples of dealing with spatial,temporal and thematic information, and solutions to them. Those are required to be well understood as a result of the course.
Should Know: Handling spatial, temporal and thematic data in creative ways. Understanding how to query only the part of data that is useful in a given aggregation, visualization or browsing function is an example of this. Included are different explorative visualization strategies, and understanding of space and time as major integrators for data. As part of this, students should know the requirements for data, and data descriptions for various visualization and application scenarios.
Nice to know: The works of other students in more detail, i.e. topics, research problems, provided methods and solutions presented in them are material in the course, and belong to this category. Students are introduced to other topics via discussion sessions, presentations, and via the peer review process where students are required to give feedback to other works.
In summary students will learn theory, techniques, presentation and organizational skills for creating explorative information visualizations.
Innehåll: In this course we study approaches for explorative information visualization. The idea is to support information usability by enabling to explore interesting patterns from datasets in visual ways. Explorative information visualization makes a joint use of efficient metaphors like hierarchies, graphs, charts, lists, maps, and timelines. The course supports students to understand the

role of hybrid methods from spatial data mining to network analytics, and from linked data to time-series handling for supporting information visualization. Our focus is on the process-thinking, thus starting from sparse datasets and to understand the tasks for iteratively making sense of data. In the course we will have a special emphasis on visualizing spatial and temporal information jointly with thematic information. The seminar builds on the idea of flipped classroom and blended learning ideas, and thus combines online learning materials with intensive face to face sessions. Online materials consist of lectures for preparing, handling and analyzing data, integrating different datasets, and for approaches to create visual demonstrations of data with maps, timelines and thematic overviews. The course consists of sessions each having a brief lecture, discussions, group works and presentations. The theoretical part of the course is deepened via our joint sessions and by individual seminar reports on selected topics.
Metoder, arbetssätt och bedömningsgrunder: Grading of the seminar is as follows: 1/3 for the seminar work, 1/3 for the opponent work, 1/3 for the active participation and presentation of the seminar work. As part of the active participation grade, students are required to prepare a one page abstract of the assigned readings / lectures in relation to her own topic.
Studiematerial: Online videos, tutorials and exercises, face to face sessions, articles.
Bedömningsskala: 0-5
Anmälning: Registration via WebOodi. Check the registration times on WebOodi.
Undervisningsspråk: English (default) or Finnish depending on implementation.

CS-E4450 Explorative Information Visualization (5 cr)

Responsible teacher: Tapio Takala; Tomi Kauppinen
Level of the Course: Master's level
Teaching Period: I – II (Autumn)
Learning Outcomes:
Learning Outcomes in three categories (must know, should know, nice to know):
Must know: Basics about how to visualize information in interactive and explorative ways.
For this the students will learn how to support information usability for creating visualizations with web technologies. Course is motivated by showing real examples of dealing with spatial,temporal and thematic information, and solutions to them. Those are required to be well understood as a result of the course.
Should Know: Handling spatial, temporal and thematic data in creative ways. Understanding how to query only the part of data that is useful in a given aggregation, visualization or browsing function is an example of this. Included are different explorative visualization strategies, and understanding of space and time as major integrators for data. As part of this, students should know the requirements for data, and data descriptions for various visualization and application scenarios.
Nice to know: The works of other students in more detail, i.e. topics, research

problems, provided methods and solutions presented in them are material in the course, and belong to this category. Students are introduced to other topics via discussion sessions, presentations, and via the peer review process where students are required to give feedback to other works.
In summary students will learn theory, techniques, presentation and organizational skills for creating explorative information visualizations.
Content: In this course we study approaches for explorative information visualization. The idea is to support information usability by enabling to explore interesting patterns from datasets in visual ways. Explorative information visualization makes a joint use of efficient metaphors like hierarchies, graphs, charts, lists, maps, and timelines. The course supports students to understand the role of hybrid methods from spatial data mining to network analytics, and from linked data to time-series handling for supporting information visualization. Our focus is on the process-thinking, thus starting from sparse datasets and to understand the tasks for iteratively making sense of data. In the course we will have a special emphasis on visualizing spatial and temporal information jointly with thematic information. The seminar builds on the idea of flipped classroom and blended learning ideas, and thus combines online learning materials with intensive face to face sessions. Online materials consist of lectures for preparing, handling and analyzing data, integrating different datasets, and for approaches to create visual demonstrations of data with maps, timelines and thematic overviews. The course consists of sessions each having a brief lecture, discussions, group works and presentations. The theoretical part of the course is deepened via our joint sessions and by individual seminar reports on selected topics.
Assessment Methods and Criteria: Grading of the seminar is as follows: 1/3 for the seminar work, 1/3 for the opponent work, 1/3 for the active participation and presentation of the seminar work. As part of the active participation grade, students are required to prepare a one page abstract of the assigned readings / lectures in relation to her own topic.
Study Material: Online videos, tutorials and exercises, face to face sessions, articles.
Grading Scale: 0-5
Registration for Courses: Registration via WebOodi. Check the registration times on WebOodi.
Language of Instruction: English (default) or Finnish depending on implementation.

CS-E4500 Advanced Course in Algorithms (5 cr)

Responsible teacher: Petteri Kaski
Level of the Course: The course is only for students who have completed their Bachelor’s degree.
Teaching period: III - IV (Spring)
Workload: Lectures: 18 (2)
Teaching in small groups: 36 (4)
Independent work: 81

Learning Outcomes: This course will deepen your knowledge and skills in algorithm design. You will become familiar with a number of advanced design principles and tradeoffs between quantities such as running time, space usage, parallel speedup, success probability, and quality of approximation.
Content: Advanced algorithm design techniques such as randomization, approximation, parameterisation, and algebrisation. Examples of contemporary advanced algorithms and supporting data structures. Tradeoffs between objectives and computational resources. The course consists of a fixed core part and a varying part covering topics of current interest.
Assessment Methods and Criteria: Points earned from weekly problem sets determine the course grade.
Study Material: Lecture notes and articles.
Substitutes for Courses: Replaces former courses T-79.5207 Advanced Course in Algorithms, T-79.5201 Discrete Structures, T-79.5202 Combinatorial Algorithms, and T-79.5203 Graph Theory.
Course Homepage: https://mycourses.aalto.fi/course/view.php?id=8914
Prerequisites: Prerequisites: Fundamentals of algorithm design and analysis (e.g. CS-E3190 /T-79.4202 Principles of Algorithmic Techniques or T-106.4100), good programming skills. First year engineering mathematics, together with an introduction to probability theory (e.g. MS-A050X). Familiarity with discrete algebraic techniques (e.g. linear programming) an asset.
Evaluation: 0-5
Language of Instruction: English.

CS-E4500 Advanced Course in Algorithms (5 sp)

Ansvarig lärare: Petteri Kaski
Kursnivå: The course is only for students who have completed their Bachelor's degree.
Undervisningsperiod: III - IV (Spring)
Arbetsmängd: Lectures: 18 (2)
Teaching in small groups: 36 (4)
Independent work: 81
Lärandemål: This course will deepen your knowledge and skills in algorithm design. You will become familiar with a number of advanced design principles and tradeoffs between quantities such as running time, space usage, parallel speedup, success probability, and quality of approximation.
Innehåll: Advanced algorithm design techniques such as randomization, approximation, parameterisation, and algebrisation. Examples of contemporary advanced algorithms and supporting data structures. Tradeoffs between objectives and computational resources. The course consists of a fixed core part and a varying part covering topics of current interest.
Metoder, arbetssätt och bedömningsgrunder: Points earned from weekly problem sets determine the course grade.
Studiematerial: Lecture notes and articles.
Ersättande prestationer: Replaces former courses T-79.5207 Advanced Course in Algorithms, T-79.5201 Discrete Structures, T-79.5202 Combinatorial

Algorithms, and T-79.5203 Graph Theory.
Kursens webbplats: https://mycourses.aalto.fi/course/view.php?id=8914
Förkunskaper: Prerequisites: Fundamentals of algorithm design and analysis (e.g. CS-E3190 /T-79.4202 Principles of Algorithmic Techniques or T-106.4100), good programming skills. First year engineering mathematics, together with an introduction to probability theory (e.g. MS-A050X). Familiarity with discrete algebraic techniques (e.g. linear programming) an asset.
Bedömningsskala: 0-5
Undervisningsspråk: English.

CS-E4500 Advanced Course in Algorithms (5 cr)

Responsible teacher: Petteri Kaski
Level of the Course: The course is only for students who have completed their Bachelor's degree.
Teaching Period: III - IV (Spring)
Workload: Lectures: 18 (2)
Teaching in small groups: 36 (4)
Independent work: 81
Learning Outcomes: This course will deepen your knowledge and skills in algorithm design. You will become familiar with a number of advanced design principles and tradeoffs between quantities such as running time, space usage, parallel speedup, success probability, and quality of approximation.
Content: Advanced algorithm design techniques such as randomization, approximation, parameterisation, and algebrisation. Examples of contemporary advanced algorithms and supporting data structures. Tradeoffs between objectives and computational resources. The course consists of a fixed core part and a varying part covering topics of current interest.
Assessment Methods and Criteria: Points earned from weekly problem sets determine the course grade.
Study Material: Lecture notes and articles.
Substitutes for Courses: Replaces former courses T-79.5207 Advanced Course in Algorithms, T-79.5201 Discrete Structures, T-79.5202 Combinatorial Algorithms, and T-79.5203 Graph Theory.
Course Homepage: https://mycourses.aalto.fi/course/view.php?id=8914
Prerequisites: Prerequisites: Fundamentals of algorithm design and analysis (e.g. CS-E3190 /T-79.4202 Principles of Algorithmic Techniques or T-106.4100), good programming skills. First year engineering mathematics, together with an introduction to probability theory (e.g. MS-A050X). Familiarity with discrete algebraic techniques (e.g. linear programming) an asset.
Grading Scale: 0-5
Language of Instruction: English.

CS-E4510 Distributed Algorithms (5 cr)

Responsible teacher: Jukka Suomela
Level of the Course: Master's level
Teaching period: I - II (Autumn)

Workload: Lectures: 24 h (1 lecture per week). Exercise sessions: 24 h (1 meeting per week). Exercises and other independent work: 79 h. Exams: 6 h (2 exams).
Learning Outcomes: After this course, you will be able to design and analyse efficient distributed algorithms for many different kinds of problems that are related to computer networks and other distributed systems. You will also know how to prove that your algorithm is as fast as possible, i.e., the same problem cannot be solved faster with any distributed algorithm. You will be able to use reductions between computational problems in the context of distributed computing, construct covering relations between graphs in order to prove impossibility results, and apply Ramsey's theorem to prove lower bounds on distributed time complexity.
Content: This course provides an introduction to the theory of distributed algorithms. The topics include algorithmic techniques that can be used to solve graph problems efficiently in extremely large networks, as well as fundamental impossibility results that set limits to distributed computing.
Assessment Methods and Criteria: Exams and exercises.
Study Material: Available online.
Substitutes for Courses: ICS-E5020 Distributed Algorithms
Prerequisites: Bachelor's degree in computer science (or equivalent). No prior knowledge of distributed systems is needed, but students are expected to have an interest in algorithmic problems and a basic knowledge of discrete mathematics.
Evaluation: 0-5
Language of Instruction: English

CS-E4510 Distributed Algorithms (5 sp)

Ansvarig lärare: Jukka Suomela
Kursnivå: Master's level
Undervisningsperiod: I - II (Autumn)
Arbetsmängd: Lectures: 24 h (1 lecture per week). Exercise sessions: 24 h (1 meeting per week). Exercises and other independent work: 79 h. Exams: 6 h (2 exams).
Lärandemål: After this course, you will be able to design and analyse efficient distributed algorithms for many different kinds of problems that are related to computer networks and other distributed systems. You will also know how to prove that your algorithm is as fast as possible, i.e., the same problem cannot be solved faster with any distributed algorithm. You will be able to use reductions between computational problems in the context of distributed computing, construct covering relations between graphs in order to prove impossibility results, and apply Ramsey's theorem to prove lower bounds on distributed time complexity.
Innehåll: This course provides an introduction to the theory of distributed algorithms. The topics include algorithmic techniques that can be used to solve graph problems efficiently in extremely large networks, as well as fundamental impossibility results that set limits to distributed computing.
Metoder, arbetssätt och bedömningsgrunder: Exams and exercises.

Studiematerial: Available online.
Ersättande prestationer: ICS-E5020 Distributed Algorithms
Förkunskaper: Bachelor's degree in computer science (or equivalent). No prior knowledge of distributed systems is needed, but students are expected to have an interest in algorithmic problems and a basic knowledge of discrete mathematics.
Bedömningsskala: 0-5
Undervisningsspråk: English

CS-E4510 Distributed Algorithms (5 cr)

Responsible teacher: Jukka Suomela
Level of the Course: Master's level
Teaching Period: I - II (Autumn)
Workload: Lectures: 24 h (1 lecture per week). Exercise sessions: 24 h (1 meeting per week). Exercises and other independent work: 79 h. Exams: 6 h (2 exams).
Learning Outcomes: After this course, you will be able to design and analyse efficient distributed algorithms for many different kinds of problems that are related to computer networks and other distributed systems. You will also know how to prove that your algorithm is as fast as possible, i.e., the same problem cannot be solved faster with any distributed algorithm. You will be able to use reductions between computational problems in the context of distributed computing, construct covering relations between graphs in order to prove impossibility results, and apply Ramsey's theorem to prove lower bounds on distributed time complexity.
Content: This course provides an introduction to the theory of distributed algorithms. The topics include algorithmic techniques that can be used to solve graph problems efficiently in extremely large networks, as well as fundamental impossibility results that set limits to distributed computing.
Assessment Methods and Criteria: Exams and exercises.
Study Material: Available online.
Substitutes for Courses: ICS-E5020 Distributed Algorithms
Prerequisites: Bachelor's degree in computer science (or equivalent). No prior knowledge of distributed systems is needed, but students are expected to have an interest in algorithmic problems and a basic knowledge of discrete mathematics.
Grading Scale: 0-5
Language of Instruction: English

CS-E4520 Computer-Aided Verification and Synthesis (5 cr)

Responsible teacher: Stavros Tripakis
Level of the Course: Master's level
Teaching period: III - IV (Spring)
Workload: There will be approximately 16 lectures of 2 hours each, biweekly homeworks, a final exam, and a project.
Learning Outcomes: The students will learn how to formally model and specify systems and their properties, and the fundamental techniques and algorithms for checking automatically that a system satisfies a property, as well as for

synthesizing automatically systems that satisfy certain properties by construction. The students will be exposed to state-of-the-art verification tools such as the model-checkers NuSMV and Spin, the SAT and SMT solvers Minisat and Z3, the theorem provers PVS and Isabelle, and synthesis tools such as Acacia+.
Content: Designing large and complex systems (digital circuits, embedded control systems such as automated vehicles, computerized health-care devices such as pacemakers, cyber-physical systems such as automated intersections, etc.) cannot be done “by hand”. Instead, designers use computer-aided techniques, that allow to build system models (”virtual systems”) and verify correctness of the design before the real system is actually built. This course covers fundamental topics in computer-aided verification, including modeling and specification formalisms, transition systems and temporal logic, regular and omega-regular languages, safety and liveness properties, state-space exploration, model checking, SAT solving, bounded-model checking, binary-decision diagrams, compositionality and assume-guarantee reasoning, contracts and component-based design. The course also covers fundamental topics in computer-aided synthesis of correct-by-construction systems, starting from high-level formal specifications, or from example scenarios.
Assessment Methods and Criteria: The grade will be based on class participation (10%), homeworks (30%), final exam (40%), and the project (20%).
Study Material: Slides, lecture notes, and research papers provided during class
Substitutes for Courses: ICS-E5010 Computer-Aided Verification and Synthesis
Prerequisites: Bachelor degree in computer science (or equivalent) recommended. Undergraduates wishing to attend are asked to email Prof. Tripakis prior to registering.
Evaluation: 0-5
Language of Instruction: English
Further Information: The course is primarily for masters, and phd-level students, but may also be appropriate for advanced undergraduates. In the latter case, please check with instructor beforehand.

CS-E4520 Computer-Aided Verification and Synthesis (5 sp)

Ansvarig lärare: Stavros Tripakis
Kursnivå: Master’s level
Undervisningsperiod: III - IV (Spring)
Arbetsmängd: There will be approximately 16 lectures of 2 hours each, biweekly homeworks, a final exam, and a project.
Lärandemål: The students will learn how to formally model and specify systems and their properties, and the fundamental techniques and algorithms for checking automatically that a system satisfies a property, as well as for synthesizing automatically systems that satisfy certain properties by construction. The students will be exposed to state-of-the-art verification tools such as the model-checkers NuSMV and Spin, the SAT and SMT solvers Minisat and Z3, the theorem provers PVS and Isabelle, and synthesis tools such as Acacia+.
Innehåll: Designing large and complex systems (digital circuits, embedded control systems such as automated vehicles, computerized health-care devices

such as pacemakers, cyber-physical systems such as automated intersections, etc.) cannot be done “by hand”. Instead, designers use computer-aided techniques, that allow to build system models (”virtual systems”) and verify correctness of the design before the real system is actually built. This course covers fundamental topics in computer-aided verification, including modeling and specification formalisms, transition systems and temporal logic, regular and omega-regular languages, safety and liveness properties, state-space exploration, model checking, SAT solving, bounded-model checking, binary-decision diagrams, compositionality and assume-guarantee reasoning, contracts and component-based design. The course also covers fundamental topics in computer-aided synthesis of correct-by-construction systems, starting from high-level formal specifications, or from example scenarios.
Metoder, arbetssätt och bedömningsgrunder: The grade will be based on class participation (10%), homeworks (30%), final exam (40%), and the project (20%).
Studiematerial: Slides, lecture notes, and research papers provided during class
Ersättande prestationer: ICS-E5010 Computer-Aided Verification and Synthesis
Förkunskaper: Bachelor degree in computer science (or equivalent) recommended. Undergraduates wishing to attend are asked to email Prof. Tripakis prior to registering.
Bedömningsskala: 0-5
Undervisningsspråk: English
Tilläggsinformation: The course is primarily for masters, and phd-level students, but may also be appropriate for advanced undergraduates. In the latter case, please check with instructor beforehand.

CS-E4520 Computer-Aided Verification and Synthesis (5 cr)

Responsible teacher: Stavros Tripakis
Level of the Course: Master’s level
Teaching Period: III - IV (Spring)
Workload: There will be approximately 16 lectures of 2 hours each, biweekly homeworks, a final exam, and a project.
Learning Outcomes: The students will learn how to formally model and specify systems and their properties, and the fundamental techniques and algorithms for checking automatically that a system satisfies a property, as well as for synthesizing automatically systems that satisfy certain properties by construction. The students will be exposed to state-of-the-art verification tools such as the model-checkers NuSMV and Spin, the SAT and SMT solvers Minisat and Z3, the theorem provers PVS and Isabelle, and synthesis tools such as Acacia+.
Content: Designing large and complex systems (digital circuits, embedded control systems such as automated vehicles, computerized health-care devices such as pacemakers, cyber-physical systems such as automated intersections, etc.) cannot be done “by hand”. Instead, designers use computer-aided techniques, that allow to build system models (”virtual systems”) and verify correctness of the design before the real system is actually built. This course covers fundamental topics in computer-aided verification, including modeling and specification

formalisms, transition systems and temporal logic, regular and omega-regular languages, safety and liveness properties, state-space exploration, model checking, SAT solving, bounded-model checking, binary-decision diagrams, compositionality and assume-guarantee reasoning, contracts and component-based design. The course also covers fundamental topics in computer-aided synthesis of correct-by-construction systems, starting from high-level formal specifications, or from example scenarios.
Assessment Methods and Criteria: The grade will be based on class participation (10%), homeworks (30%), final exam (40%), and the project (20%).
Study Material: Slides, lecture notes, and research papers provided during class
Substitutes for Courses: ICS-E5010 Computer-Aided Verification and Synthesis
Prerequisites: Bachelor degree in computer science (or equivalent) recommended. Undergraduates wishing to attend are asked to email Prof. Tripakis prior to registering.
Grading Scale: 0-5
Language of Instruction: English
Further Information: The course is primarily for masters, and phd-level students, but may also be appropriate for advanced undergraduates. In the latter case, please check with instructor beforehand.

CS-E4530 Computational Complexity Theory (5 cr)

Responsible teacher: Christopher Purcell
Level of the Course: The course is only for students who have completed their Bachelor's degree.
Teaching period: III - IV (Spring)
Workload: Lectures: 36 Examinations: 3 Homework assignments: 56 Other independent work (including preparing for the examinations): 39
Learning Outcomes: Once you have taken the course, you master the key complexity classes, their underlying models of computation, and relationships. You are able to formalise and abstract from a given computational task relevant computational problems and argue that they belong to appropriate complexity classes. You understand the concept of reductions and how it can be used to order problems by their computational complexity. You are able to show using reductions that a problem is complete for a central complexity class (such as NP) and you understand the importance and implications of such a result. You are familiar with the concepts of randomised, approximation, and parallel algorithms and aware of related complexity classes and their relation to other complexity classes and their models of computation.
Content: Reductions and NP-completeness. Class coNP, structure of NP, relativisations. The polynomial time hierarchy and alternating Turing machines. Boolean circuits and parallel computation. Randomised computation. Cryptography and complexity. Approximability. Counting classes, PSPACE and beyond.
Assessment Methods and Criteria: Homework assignments and final exam. The grade of the course is determined by the respective grades of the homework assignments (50%) and the final exam (50%).

Study Material: C. Papadimitriou: Computational Complexity, Addison-Wesley, 1994. S. Arora and B. Barak: Computational Complexity – A Modern Approach, Cambridge U.P. 2009.
Substitutes for Courses: T-79.5103 Computational Complexity Theory
Prerequisites: Automata and formal languages. Deterministic and nondeterministic Turing machines. Decidable and undecidable problems (e.g. CS-C2150 / ICS-C2000 Theoretical Computer Science).
Evaluation: 0-5
Language of Instruction: English.

CS-E4530 Computational Complexity Theory (5 sp)

Ansvarig lärare: Christopher Purcell
Kursnivå: The course is only for students who have completed their Bachelor's degree.
Undervisningsperiod: III - IV (Spring)
Arbetsmängd: Lectures: 36 Examinations: 3 Homework assignments: 56 Other independent work (including preparing for the examinations): 39
Lärandemål: Once you have taken the course, you master the key complexity classes, their underlying models of computation, and relationships. You are able to formalise and abstract from a given computational task relevant computational problems and argue that they belong to appropriate complexity classes. You understand the concept of reductions and how it can be used to order problems by their computational complexity. You are able to show using reductions that a problem is complete for a central complexity class (such as NP) and you understand the importance and implications of such a result. You are familiar with the concepts of randomised, approximation, and parallel algorithms and aware of related complexity classes and their relation to other complexity classes and their models of computation.
Innehåll: Reductions and NP-completeness. Class coNP, structure of NP, relativisations. The polynomial time hierarchy and alternating Turing machines. Boolean circuits and parallel computation. Randomised computation. Cryptography and complexity. Approximability. Counting classes, PSPACE and beyond.
Metoder, arbetssätt och bedömningsgrunder: Homework assignments and final exam. The grade of the course is determined by the respective grades of the homework assignments (50%) and the final exam (50%).
Studiematerial: C. Papadimitriou: Computational Complexity, Addison-Wesley, 1994. S. Arora and B. Barak: Computational Complexity – A Modern Approach, Cambridge U.P. 2009.
Ersättande prestationer: T-79.5103 Computational Complexity Theory
Förkunskaper: Automata and formal languages. Deterministic and nondeterministic Turing machines. Decidable and undecidable problems (e.g. CS-C2150 / ICS-C2000 Theoretical Computer Science).
Bedömningsskala: 0-5
Undervisningsspråk: English.

CS-E4530 Computational Complexity Theory (5 cr)

Responsible teacher: Christopher Purcell
Level of the Course: The course is only for students who have completed their Bachelor's degree.
Teaching Period: III - IV (Spring)
Workload: Lectures: 36 Examinations: 3 Homework assignments: 56 Other independent work (including preparing for the examinations): 39
Learning Outcomes: Once you have taken the course, you master the key complexity classes, their underlying models of computation, and relationships. You are able to formalise and abstract from a given computational task relevant computational problems and argue that they belong to appropriate complexity classes. You understand the concept of reductions and how it can be used to order problems by their computational complexity. You are able to show using reductions that a problem is complete for a central complexity class (such as NP) and you understand the importance and implications of such a result. You are familiar with the concepts of randomised, approximation, and parallel algorithms and aware of related complexity classes and their relation to other complexity classes and their models of computation.
Content: Reductions and NP-completeness. Class coNP, structure of NP, relativisations. The polynomial time hierarchy and alternating Turing machines. Boolean circuits and parallel computation. Randomised computation. Cryptography and complexity. Approximability. Counting classes, PSPACE and beyond.
Assessment Methods and Criteria: Homework assignments and final exam. The grade of the course is determined by the respective grades of the homework assignments (50%) and the final exam (50%).
Study Material: C. Papadimitriou: Computational Complexity, Addison-Wesley, 1994. S. Arora and B. Barak: Computational Complexity – A Modern Approach, Cambridge U.P. 2009.
Substitutes for Courses: T-79.5103 Computational Complexity Theory
Prerequisites: Automata and formal languages. Deterministic and nondeterministic Turing machines. Decidable and undecidable problems (e.g. CS-C2150 / ICS-C2000 Theoretical Computer Science).
Grading Scale: 0-5
Language of Instruction: English.

CS-E4540 Answer Set Programming (5 cr)

Responsible teacher: Tomi Janhunen
Level of the Course: The course is only for students who have completed their Bachelor's degree.
Teaching period: I - II (Autumn)
Workload: Lectures: 20
Teaching in small groups: 20
Independent work: 90
Examination: 3
Learning Outcomes: Once you have completed the course you have an in-depth

understanding of the ASP methodology. You have practical modeling/programming skills using current ASP tools and systems. You are also aware of some applications and their main characteristics. Moreover, you have a basic understanding of the theoretical background of ASP.
Content: Introduction to basic syntactic primitives used in answer set programming: rules, default negation, and various kinds of extensions to rules. Modeling different kinds of systems and problems with rules. Computational complexity of the main decision problems. Alternative characterizations of answer sets. Answer set solving techniques. Verification and modularity of answer-set programs.
Assessment Methods and Criteria: Exam and compulsory home assignments. The overall course grade depends on the grades earned for the exam and the home assignments. Bonus points for the examination can be earned by solving exercise problems.
Substitutes for Courses: T-79.5105 Answer Set Programming
Course Homepage: https://mycourses.aalto.fi/course/view.php?id=8911
Prerequisites: Basics of propositional logic (e.g., CS-E3200 / T-79.4101 Discrete Models and Search or CS-E4800 / ICS-E4000 Artificial Intelligence).
Evaluation: 0-5
Language of Instruction: English.

CS-E4540 Answer Set Programming (5 sp)

Ansvarig lärare: Tomi Janhunen
Kursnivå: The course is only for students who have completed their Bachelor's degree.
Undervisningsperiod: I - II (Autumn)
Arbetsmängd: Lectures: 20
Teaching in small groups: 20
Independent work: 90
Examination: 3
Lärandemål: Once you have completed the course you have an in-depth understanding of the ASP methodology. You have practical modeling/programming skills using current ASP tools and systems. You are also aware of some applications and their main characteristics. Moreover, you have a basic understanding of the theoretical background of ASP.
Innehåll: Introduction to basic syntactic primitives used in answer set programming: rules, default negation, and various kinds of extensions to rules. Modeling different kinds of systems and problems with rules. Computational complexity of the main decision problems. Alternative characterizations of answer sets. Answer set solving techniques. Verification and modularity of answer-set programs.
Metoder, arbetssätt och bedömningsgrunder: Exam and compulsory home assignments. The overall course grade depends on the grades earned for the exam and the home assignments. Bonus points for the examination can be earned by solving exercise problems.
Ersättande prestationer: T-79.5105 Answer Set Programming

Kursens webbplats: https://mycourses.aalto.fi/course/view.php?id=8911
Förkunskaper: Basics of propositional logic (e.g., CS-E3200 / T-79.4101 Discrete Models and Search or CS-E4800 / ICS-E4000 Artificial Intelligence).
Bedömningsskala: 0-5
Undervisningsspråk: English.

CS-E4540 Answer Set Programming (5 cr)

Responsible teacher: Tomi Janhunen
Level of the Course: The course is only for students who have completed their Bachelor's degree.
Teaching Period: I - II (Autumn)
Workload: Lectures: 20
Teaching in small groups: 20
Independent work: 90
Examination: 3
Learning Outcomes: Once you have completed the course you have an in-depth understanding of the ASP methodology. You have practical modeling/programming skills using current ASP tools and systems. You are also aware of some applications and their main characteristics. Moreover, you have a basic understanding of the theoretical background of ASP.
Content: Introduction to basic syntactic primitives used in answer set programming: rules, default negation, and various kinds of extensions to rules. Modeling different kinds of systems and problems with rules. Computational complexity of the main decision problems. Alternative characterizations of answer sets. Answer set solving techniques. Verification and modularity of answer-set programs.
Assessment Methods and Criteria: Exam and compulsory home assignments. The overall course grade depends on the grades earned for the exam and the home assignments. Bonus points for the examination can be earned by solving exercise problems.
Substitutes for Courses: T-79.5105 Answer Set Programming
Course Homepage: https://mycourses.aalto.fi/course/view.php?id=8911
Prerequisites: Basics of propositional logic (e.g., CS-E3200 / T-79.4101 Discrete Models and Search or CS-E4800 / ICS-E4000 Artificial Intelligence).
Grading Scale: 0-5
Language of Instruction: English.

CS-E4550 Advanced Combinatorics in Computer Science(V) (5 cr)

Responsible teacher: Petteri Kaski
Level of the Course: Master's level
Teaching period: I-II
Workload: Lectures: 10 (2)
Teaching in small groups: 20 (4)
Independent work: 105 (solving biweekly problems)
Learning Outcomes: Once you have taken this course you have received an in-depth introduction to a topic in advanced combinatorics with its applications in

computer science. The course has varying content and the precise learning outcomes vary by Instance.
Content: Lectured biennially. The Autumn 2016 instance will study pseudorandomness and explicit pseudorandom constructions (e.g. expander graphs) in algorithms and complexity. Not lectured in Autumn 2017. The Autumn 2018 instance will study the polynomial method in fine-grained complexity and algorithm design.
Assessment Methods and Criteria: Points earned from biweekly problem sets determine the course grade.
Study Material: Lecture notes and articles.
Substitutes for Courses: ICS-E5030 Advanced Combinatorics in Computer Science, T-79.5205 Combinatorics L
Course Homepage: To be announced later.
Prerequisites: Mathematical maturity, including at least the basics of discrete mathematics (e.g. MS-A0401 or MS-A0402) and algorithm design (e.g. CS-E3190 / T-79.4202 or T-106.4100). Familiarity with combinatorics (e.g. MS-C1050) a strong asset.
Evaluation: 0-5
Language of Instruction: English
Further Information: The contents of the course vary.

CS-E4550 Advanced Combinatorics in Computer Science(V) (5 sp)

Ansvarig lärare: Petteri Kaski
Kursnivå: Master's level
Undervisningsperiod: I-II
Arbetsmängd: Lectures: 10 (2)
Teaching in small groups: 20 (4)
Independent work: 105 (solving biweekly problems)
Lärandemål: Once you have taken this course you have received an in-depth introduction to a topic in advanced combinatorics with its applications in computer science. The course has varying content and the precise learning outcomes vary by Instance.
Innehåll: Lectured biennially. The Autumn 2016 instance will study pseudorandomness and explicit pseudorandom constructions (e.g. expander graphs) in algorithms and complexity. Not lectured in Autumn 2017. The Autumn 2018 instance will study the polynomial method in fine-grained complexity and algorithm design.
Metoder, arbetssätt och bedömningsgrunder: Points earned from biweekly problem sets determine the course grade.
Studiematerial: Lecture notes and articles.
Ersättande prestationer: ICS-E5030 Advanced Combinatorics in Computer Science, T-79.5205 Combinatorics L
Kursens webbplats: To be announced later.
Förkunskaper: Mathematical maturity, including at least the basics of discrete mathematics (e.g. MS-A0401 or MS-A0402) and algorithm design (e.g. CS-E3190 / T-79.4202 or T-106.4100). Familiarity with combinatorics (e.g.

MS-C1050) a strong asset.
Bedömningsskala: 0-5
Undervisningsspråk: English
Tilläggsinformation: The contents of the course vary.

CS-E4550 Advanced Combinatorics in Computer Science(V) (5 cr)

Responsible teacher: Petteri Kaski
Level of the Course: Master's level
Teaching Period: I-II
Workload: Lectures: 10 (2)
Teaching in small groups: 20 (4)
Independent work: 105 (solving biweekly problems)
Learning Outcomes: Once you have taken this course you have received an in-depth introduction to a topic in advanced combinatorics with its applications in computer science. The course has varying content and the precise learning outcomes vary by Instance.
Content: Lectured biennially. The Autumn 2016 instance will study pseudorandomness and explicit pseudorandom constructions (e.g. expander graphs) in algorithms and complexity. Not lectured in Autumn 2017. The Autumn 2018 instance will study the polynomial method in fine-grained complexity and algorithm design.
Assessment Methods and Criteria: Points earned from biweekly problem sets determine the course grade.
Study Material: Lecture notes and articles.
Substitutes for Courses: ICS-E5030 Advanced Combinatorics in Computer Science, T-79.5205 Combinatorics L
Course Homepage: To be announced later.
Prerequisites: Mathematical maturity, including at least the basics of discrete mathematics (e.g. MS-A0401 or MS-A0402) and algorithm design (e.g. CS-E3190 / T-79.4202 or T-106.4100). Familiarity with combinatorics (e.g. MS-C1050) a strong asset.
Grading Scale: 0-5
Language of Instruction: English
Further Information: The contents of the course vary.

CS-E4560 Parallel and Distributed Systems (5 cr)

Responsible teacher: Stavros Tripakis
Level of the Course: The course is only for students who have completed their general studies.
Teaching period: I - II (Autumn)
Workload: Contact teaching 44 h (2 h lectures per week for 12 weeks and 2 h exercises per week for 10 weeks). Independent work 96 h (preparing for contact sessions, project assignments, peer assessment, revising for the exam). Exam 3 h.
Learning Outcomes: After completing this course, you will be able to define the behavior of parallel and distributed systems in a rigorous way, discuss the challenge of concurrency-related design errors, and explain central analysis

techniques for verifying parallel and distributed systems. You will be able to construct accurate formal models of small parallel and distributed systems and use a model checking tool to automatically verify several standard properties of the models. You will also be able to explain the central difficulties in analyzing systems caused by the state explosion problem, explain and apply central theoretical concepts of the area, and modify your models to reduce state explosion.
Content: Modelling of parallel and distributed computer systems. Theoretical aspects of concurrent systems. Basics of specification methods including temporal logic. Algorithms and tools for computer aided verification of properties.
Assessment Methods and Criteria: Project assignments (20%), in-class exercises prepared at home (20%), and exam (60%).
Study Material: Lecture slides, tutorial problems, and tutorial solutions.
Substitutes for Courses: Replaces former courses T-79.4302 / T-79.4301 Parallel and Distributed Systems.
Prerequisites: Basic theoretical computer science including automata theory (e.g. CS-C2150 / ICS-C2000 Theoretical Computer Science), logic in computer science (e.g. CS-E3200 / T-79.4101 Discrete Models and Search), and basics of multithreaded programming (e.g. CS-A1121 / CSE-A1121 Basic Course in Programming Y2).
Evaluation: 0-5
Language of Instruction: English.

CS-E4560 Parallel and Distributed Systems (5 sp)

Ansvarig lärare: Stavros Tripakis
Kursnivå: The course is only for students who have completed their general studies.
Undervisningsperiod: I - II (Autumn)
Arbetsmängd: Contact teaching 44 h (2 h lectures per week for 12 weeks and 2 h exercises per week for 10 weeks). Independent work 96 h (preparing for contact sessions, project assignments, peer assessment, revising for the exam). Exam 3 h.
Lärandemål: After completing this course, you will be able to define the behavior of parallel and distributed systems in a rigorous way, discuss the challenge of concurrency-related design errors, and explain central analysis techniques for verifying parallel and distributed systems. You will be able to construct accurate formal models of small parallel and distributed systems and use a model checking tool to automatically verify several standard properties of the models. You will also be able to explain the central difficulties in analyzing systems caused by the state explosion problem, explain and apply central theoretical concepts of the area, and modify your models to reduce state explosion.
Innehåll: Modelling of parallel and distributed computer systems. Theoretical aspects of concurrent systems. Basics of specification methods including temporal logic. Algorithms and tools for computer aided verification of properties.
Metoder, arbetssätt och bedömningsgrunder: Project assignments (20%), in-class exercises prepared at home (20%), and exam (60%).

Studiematerial: Lecture slides, tutorial problems, and tutorial solutions.
Ersättande prestationer: Replaces former courses T-79.4302 / T-79.4301 Parallel and Distributed Systems.
Förkunskaper: Basic theoretical computer science including automata theory (e.g. CS-C2150 / ICS-C2000 Theoretical Computer Science), logic in computer science (e.g. CS-E3200 / T-79.4101 Discrete Models and Search), and basics of multithreaded programming (e.g. CS-A1121 / CSE-A1121 Basic Course in Programming Y2).
Bedömningsskala: 0-5
Undervisningsspråk: English.

CS-E4560 Parallel and Distributed Systems (5 cr)

Responsible teacher: Stavros Tripakis
Level of the Course: The course is only for students who have completed their general studies.
Teaching Period: I - II (Autumn)
Workload: Contact teaching 44 h (2 h lectures per week for 12 weeks and 2 h exercises per week for 10 weeks). Independent work 96 h (preparing for contact sessions, project assignments, peer assessment, revising for the exam). Exam 3 h.
Learning Outcomes: After completing this course, you will be able to define the behavior of parallel and distributed systems in a rigorous way, discuss the challenge of concurrency-related design errors, and explain central analysis techniques for verifying parallel and distributed systems. You will be able to construct accurate formal models of small parallel and distributed systems and use a model checking tool to automatically verify several standard properties of the models. You will also be able to explain the central difficulties in analyzing systems caused by the state explosion problem, explain and apply central theoretical concepts of the area, and modify your models to reduce state explosion.
Content: Modelling of parallel and distributed computer systems. Theoretical aspects of concurrent systems. Basics of specification methods including temporal logic. Algorithms and tools for computer aided verification of properties.
Assessment Methods and Criteria: Project assignments (20%), in-class exercises prepared at home (20%), and exam (60%).
Study Material: Lecture slides, tutorial problems, and tutorial solutions.
Substitutes for Courses: Replaces former courses T-79.4302 / T-79.4301 Parallel and Distributed Systems.
Prerequisites: Basic theoretical computer science including automata theory (e.g. CS-C2150 / ICS-C2000 Theoretical Computer Science), logic in computer science (e.g. CS-E3200 / T-79.4101 Discrete Models and Search), and basics of multithreaded programming (e.g. CS-A1121 / CSE-A1121 Basic Course in Programming Y2).
Grading Scale: 0-5
Language of Instruction: English.

CS-E4570 Advanced Course in Boolean Satisfiability (5 cr)

Responsible teacher: Tommi Junttila; Jussi Rintanen; Tomi Janhunen
Level of the Course: Master's level
Teaching period: V
Workload: Lectures: 20
Teaching in small groups: 20
Independent work: 90
Examination: 3
Learning Outcomes: Once you have completed the course you have an in-depth understanding of algorithms and representations for Boolean satisfiability and propositional logic. You have practical modeling skills and familiarity with applications and their main characteristics.
Content: Selected topics on Boolean satisfiability such as efficient representations for Boolean functions, algorithms for satisfiability checking (e.g., DPLL, CDCL) and model counting, extensions of Boolean satisfiability (e.g., maximum satisfiability, satisfiability modulo theories), proof systems.
Assessment Methods and Criteria: Exam and compulsory home assignments. The overall course grade depends on the grades earned for the exam and the home assignments. Bonus points for the examination can be earned by solving exercise problems.
Study Material: Lecture slides and articles.
Substitutes for Courses: ICS-E5050 Advanced Course in Boolean Satisfiability, T-79.5104 Advanced Course in Computational Logic.
Prerequisites: Basics of propositional logic (e.g., CS-E3200 / T-79.4101 Discrete Models and Search or CS-E4800 / ICS-E4000 Artificial Intelligence).
Evaluation: 0-5
Language of Instruction: English

CS-E4570 Advanced Course in Boolean Satisfiability (5 sp)

Ansvarig lärare: Tommi Junttila; Jussi Rintanen; Tomi Janhunen
Kursnivå: Master's level
Undervisningsperiod: V
Arbetsmängd: Lectures: 20
Teaching in small groups: 20
Independent work: 90
Examination: 3
Lärandemål: Once you have completed the course you have an in-depth understanding of algorithms and representations for Boolean satisfiability and propositional logic. You have practical modeling skills and familiarity with applications and their main characteristics.
Innehåll: Selected topics on Boolean satisfiability such as efficient representations for Boolean functions, algorithms for satisfiability checking (e.g., DPLL, CDCL) and model counting, extensions of Boolean satisfiability (e.g., maximum satisfiability, satisfiability modulo theories), proof systems.
Metoder, arbetssätt och bedömningsgrunder: Exam and compulsory home assignments. The overall course grade depends on the grades earned for the exam and the home assignments. Bonus points for the examination can be earned by

solving exercise problems.
Studiematerial: Lecture slides and articles.
Ersättande prestationer: ICS-E5050 Advanced Course in Boolean Satisfiability, T-79.5104 Advanced Course in Computational Logic.
Förkunskaper: Basics of propositional logic (e.g., CS-E3200 / T-79.4101 Discrete Models and Search or CS-E4800 / ICS-E4000 Artificial Intelligence).
Bedömningsskala: 0-5
Undervisningsspråk: English

CS-E4570 Advanced Course in Boolean Satisfiability (5 cr)

Responsible teacher: Tommi Junttila; Jussi Rintanen; Tomi Janhunen
Level of the Course: Master's level
Teaching Period: V
Workload: Lectures: 20
Teaching in small groups: 20
Independent work: 90
Examination: 3
Learning Outcomes: Once you have completed the course you have an in-depth understanding of algorithms and representations for Boolean satisfiability and propositional logic. You have practical modeling skills and familiarity with applications and their main characteristics.
Content: Selected topics on Boolean satisfiability such as efficient representations for Boolean functions, algorithms for satisfiability checking (e.g., DPLL, CDCL) and model counting, extensions of Boolean satisfiability (e.g., maximum satisfiability, satisfiability modulo theories), proof systems.
Assessment Methods and Criteria: Exam and compulsory home assignments. The overall course grade depends on the grades earned for the exam and the home assignments. Bonus points for the examination can be earned by solving exercise problems.
Study Material: Lecture slides and articles.
Substitutes for Courses: ICS-E5050 Advanced Course in Boolean Satisfiability, T-79.5104 Advanced Course in Computational Logic.
Prerequisites: Basics of propositional logic (e.g., CS-E3200 / T-79.4101 Discrete Models and Search or CS-E4800 / ICS-E4000 Artificial Intelligence).
Grading Scale: 0-5
Language of Instruction: English

CS-E4580 Programming Parallel Computers (5 cr)

Responsible teacher: Jukka Suomela
Status of the Course: Optional course of the Game Design amd Production major.
Level of the Course: Master's level
Teaching period: V (Spring)
Workload: Lectures: 12 h (1 lecture per week). Exercise sessions: 24 h (2 meetings per week). Programming assignments and other independent work: 97 h.
Learning Outcomes: After this course, you will know how to write

computationally intensive C or C++ code that makes an efficient use of dozens of CPU cores. You will learn how to partition large-scale computations between multiple processor cores, and how to choose the best memory layout for your data structures. You will also get hands-on experience of offloading computations from CPUs to GPUs. You will learn new kinds of algorithm design techniques that are relevant in the context of parallel computers, and you will also learn which of these techniques actually work in practice on modern multicore CPUs and GPUs.
Content: This is a practical hands-on course on algorithm engineering for modern parallel computers. The students will learn how to design programs that make the best possible use of the computing power of multicore CPUs and GPUs. The course projects will cover both numerical and combinatorial problems; the sole objective is to solve the task at hand in the shortest possible time. We will learn a whole range of techniques for speeding up computations, from bit manipulation hacks and special CPU instructions to high-level techniques such as choosing the right memory layout that makes the best possible use of the cache hierarchy. The main tools that we will use are C or C++, OpenMP or Intel TBB, and OpenCL or CUDA.
Assessment Methods and Criteria: Programming exercises.
Study Material: Available online.
Substitutes for Courses: ICS-E4020 Programming Parallel Computers
Prerequisites: No prior knowledge of parallel programming is needed. Students should have a good understanding of computer programming, algorithms and data structures, and a working knowledge of either C or C++ programming language. While this course is primarily targeted to Master students, advanced Bachelor students are welcome to join if they have sufficient background knowledge and programming skills. At the minimum, students should have completed all 1st year and 2nd year courses of their Bachelor degree.
Evaluation: 0-5
Language of Instruction: English

CS-E4580 Programming Parallel Computers (5 sp)

Ansvarig lärare: Jukka Suomela
Kursens status: Optional course of the Game Design amd Production major.
Kursnivå: Master's level
Undervisningsperiod: V (Spring)
Arbetsmängd: Lectures: 12 h (1 lecture per week). Exercise sessions: 24 h (2 meetings per week). Programming assignments and other independent work: 97 h.
Lärandemål: After this course, you will know how to write computationally intensive C or C++ code that makes an efficient use of dozens of CPU cores. You will learn how to partition large-scale computations between multiple processor cores, and how to choose the best memory layout for your data structures. You will also get hands-on experience of offloading computations from CPUs to GPUs. You will learn new kinds of algorithm design techniques that are relevant in the context of parallel computers, and you will also learn which of these techniques actually work in practice on modern multicore CPUs and GPUs.

Innehåll: This is a practical hands-on course on algorithm engineering for modern parallel computers. The students will learn how to design programs that make the best possible use of the computing power of multicore CPUs and GPUs. The course projects will cover both numerical and combinatorial problems; the sole objective is to solve the task at hand in the shortest possible time. We will learn a whole range of techniques for speeding up computations, from bit manipulation hacks and special CPU instructions to high-level techniques such as choosing the right memory layout that makes the best possible use of the cache hierarchy. The main tools that we will use are C or C++, OpenMP or Intel TBB, and OpenCL or CUDA.
Metoder, arbetssätt och bedömningsgrunder: Programming exercises.
Studiematerial: Available online.
Ersättande prestationer: ICS-E4020 Programming Parallel Computers
Förkunskaper: No prior knowledge of parallel programming is needed. Students should have a good understanding of computer programming, algorithms and data structures, and a working knowledge of either C or C++ programming language. While this course is primarily targeted to Master students, advanced Bachelor students are welcome to join if they have sufficient background knowledge and programming skills. At the minimum, students should have completed all 1st year and 2nd year courses of their Bachelor degree.
Bedömningsskala: 0-5
Undervisningsspråk: English

CS-E4580 Programming Parallel Computers (5 cr)

Responsible teacher: Jukka Suomela
Status of the Course: Optional course of the Game Design amd Production major.
Level of the Course: Master's level
Teaching Period: V (Spring)
Workload: Lectures: 12 h (1 lecture per week). Exercise sessions: 24 h (2 meetings per week). Programming assignments and other independent work: 97 h.
Learning Outcomes: After this course, you will know how to write computationally intensive C or C++ code that makes an efficient use of dozens of CPU cores. You will learn how to partition large-scale computations between multiple processor cores, and how to choose the best memory layout for your data structures. You will also get hands-on experience of offloading computations from CPUs to GPUs. You will learn new kinds of algorithm design techniques that are relevant in the context of parallel computers, and you will also learn which of these techniques actually work in practice on modern multicore CPUs and GPUs.
Content: This is a practical hands-on course on algorithm engineering for modern parallel computers. The students will learn how to design programs that make the best possible use of the computing power of multicore CPUs and GPUs. The course projects will cover both numerical and combinatorial problems; the sole objective is to solve the task at hand in the shortest possible time. We will learn a whole range of techniques for speeding up computations, from bit manipulation

hacks and special CPU instructions to high-level techniques such as choosing the right memory layout that makes the best possible use of the cache hierarchy. The main tools that we will use are C or C++, OpenMP or Intel TBB, and OpenCL or CUDA.
Assessment Methods and Criteria: Programming exercises.
Study Material: Available online.
Substitutes for Courses: ICS-E4020 Programming Parallel Computers
Prerequisites: No prior knowledge of parallel programming is needed. Students should have a good understanding of computer programming, algorithms and data structures, and a working knowledge of either C or C++ programming language. While this course is primarily targeted to Master students, advanced Bachelor students are welcome to join if they have sufficient background knowledge and programming skills. At the minimum, students should have completed all 1st year and 2nd year courses of their Bachelor degree.
Grading Scale: 0-5
Language of Instruction: English

CS-E4590 Competitive Programming(V) (2-5 cr)

Responsible teacher: Jukka Suomela
Level of the Course: The course is suitable for both bachelor's and master's students.
Teaching period: I-II
Workload: Depends on the assignments.
Learning Outcomes: You will learn how to solve algorithmic programming challenges, both individually and as a team. You will be able to design and implement efficient algorithms for challenging computational problems, in practice, quickly and correctly.
Content: This is a practical hands-on course. We will meet once a week in a computer lab and organise a mini-contest. During the course, you will also take part in NCPC, Nordic Collegiate Programming Contest.
Assessment Methods and Criteria: Programming challenges.
Study Material: Available online.
Prerequisites: Students are expected to have a working knowledge of computer programming, algorithms, and data structures, and preferably some practical experience with C or C++ programming languages.
Evaluation: pass/fail
Language of Instruction: English
Further Information: The content of the course varies.

CS-E4590 Competitive Programming(V) (2-5 sp)

Ansvarig lärare: Jukka Suomela
Kursnivå: The course is suitable for both bachelor's and master's students.
Undervisningsperiod: I-II
Arbetsmängd: Depends on the assignments.
Lärandemål: You will learn how to solve algorithmic programming challenges, both individually and as a team. You will be able to design and implement

efficient algorithms for challenging computational problems, in practice, quickly and correctly.
Innehåll: This is a practical hands-on course. We will meet once a week in a computer lab and organise a mini-contest. During the course, you will also take part in NCPC, Nordic Collegiate Programming Contest.
Metoder, arbetssätt och bedömningsgrunder: Programming challenges.
Studiematerial: Available online.
Förkunskaper: Students are expected to have a working knowledge of computer programming, algorithms, and data structures, and preferably some practical experience with C or C++ programming languages.
Bedömningsskala: pass/fail
Undervisningsspråk: English
Tilläggsinformation: The content of the course varies.

CS-E4590 Competitive Programming(V) (2-5 cr)

Responsible teacher: Jukka Suomela
Level of the Course: The course is suitable for both bachelor's and master's students.
Teaching Period: I-II
Workload: Depends on the assignments.
Learning Outcomes: You will learn how to solve algorithmic programming challenges, both individually and as a team. You will be able to design and implement efficient algorithms for challenging computational problems, in practice, quickly and correctly.
Content: This is a practical hands-on course. We will meet once a week in a computer lab and organise a mini-contest. During the course, you will also take part in NCPC, Nordic Collegiate Programming Contest.
Assessment Methods and Criteria: Programming challenges.
Study Material: Available online.
Prerequisites: Students are expected to have a working knowledge of computer programming, algorithms, and data structures, and preferably some practical experience with C or C++ programming languages.
Grading Scale: pass/fail
Language of Instruction: English
Further Information: The content of the course varies.

CS-E4600 Algorithmic Methods of Data Mining (5 cr)

Responsible teacher: Aristides Gionis
Teaching period: I - II (Autumn)
Workload: 24 + 12 (4 + 2)
Learning Outcomes: The students will familiarize themselves with basic data-mining principles and methods. The course will cover different problem scenarios, such as, pattern discovery, clustering, and ordering, as well as, analysis of different types of data, such as, sets, graphs, and sequences. The students will develop their analytical tehniques to cope with challenging data-analysis problems. They will also develop their practical skills through

programming assignments and experimentation with real data.
Content: The course covers general topics in data mining, such as pattern discovery, similarity search, data clustering, graph mining, ranking and ordering problems, stream computation, and distributed analysis of data, such as map-reduce.
Assessment Methods and Criteria: Take-home homeworks, programming assignments, and in-class final exam.
Study Material: Lecture slides and online lecture notes.
Substitutes for Courses: T-61.5060 Algorithmic Methods of Data Mining
Prerequisites: Basic mathematics, statistics, and basic courses on algorithms design.
Evaluation: 0-5
Language of Instruction: English

CS-E4600 Algorithmic Methods of Data Mining (5 sp)

Ansvarig lärare: Aristides Gionis
Undervisningsperiod: I - II (Autumn)
Arbetsmängd: 24 + 12 (4 + 2)
Lärandemål: The students will familiarize themselves with basic data-mining principles and methods. The course will cover different problem scenarios, such as, pattern discovery, clustering, and ordering, as well as, analysis of different types of data, such as, sets, graphs, and sequences. The students will develop their analytical tehniques to cope with challenging
data-analysis problems. They will also develop their practical skills through programming assignments and experimentation with real data.
Innehåll: The course covers general topics in data mining, such as pattern discovery, similarity search, data clustering, graph mining, ranking and ordering problems, stream computation, and distributed analysis of data, such as map-reduce.
Metoder, arbetssätt och bedömningsgrunder: Take-home homeworks, programming assignments, and in-class final exam.
Studiematerial: Lecture slides and online lecture notes.
Ersättande prestationer: T-61.5060 Algorithmic Methods of Data Mining
Förkunskaper: Basic mathematics, statistics, and basic courses on algorithms design.
Bedömningsskala: 0-5
Undervisningsspråk: English

CS-E4600 Algorithmic Methods of Data Mining (5 cr)

Responsible teacher: Aristides Gionis
Teaching Period: I - II (Autumn)
Workload: 24 + 12 (4 + 2)
Learning Outcomes: The students will familiarize themselves with basic data-mining principles and methods. The course will cover different problem scenarios, such as, pattern discovery, clustering, and ordering, as well as, analysis of different types of data, such as, sets, graphs, and sequences. The students will

develop their analytical tehniques to cope with challenging
data-analysis problems. They will also develop their practical skills through programming assignments and experimentation with real data.
Content: The course covers general topics in data mining, such as pattern discovery, similarity search, data clustering, graph mining, ranking and ordering problems, stream computation, and distributed analysis of data, such as map-reduce.
Assessment Methods and Criteria: Take-home homeworks, programming assignments, and in-class final exam.
Study Material: Lecture slides and online lecture notes.
Substitutes for Courses: T-61.5060 Algorithmic Methods of Data Mining
Prerequisites: Basic mathematics, statistics, and basic courses on algorithms design.
Grading Scale: 0-5
Language of Instruction: English

CS-E4610 Modern Database Systems (5 cr)

Responsible teacher: Aristides Gionis
Level of the Course: Master's level
Teaching period: III-IV
Workload: Lectures: 2h/week, Independent study: 2h/week, Homeworks: 4h/week, Projects: 20h total
Learning Outcomes: Upon completion of the course, the students should be able to understand and cope successfully with various aspects of data management in modern database systems. Emphasis will be given in managing data that have complex structure, such as, text data, web data, social data, etc. Algorithms for approximate query answering and scalable data processing will be studied. The students will also have the opportunity to study platforms for managing big data, such as, map-reduce, platforms for data streams, and platforms for graph data.
Content: A tentative list of topics includes: algorithms for query optimization, data warehousing and OLAP, approximate query answering, scalable data analysis, managing text data, managing web data, managing semi-structured data, distributed hash-tables, data cleaning, platforms for big data.
Assessment Methods and Criteria: Take-home homeworks, programming assignments, and in-class final exam.
Study Material: Lecture slides and online lecture notes.
Substitutes for Courses: ICS-E5040 Modern Database Systems
Prerequisites: Basics in mathematics and computer science. Knowledge of data structures.
Evaluation: 0-5
Language of Instruction: English

CS-E4610 Modern Database Systems (5 sp)

Ansvarig lärare: Aristides Gionis
Kursnivå: Master's level
Undervisningsperiod: III-IV

Arbetsmängd: Lectures: 2h/week, Independent study: 2h/week, Homeworks: 4h/week, Projects: 20h total
Lärandemål: Upon completion of the course, the students should be able to understand and cope successfully with various aspects of data management in modern database systems. Emphasis will be given in managing data that have complex structure, such as, text data, web data, social data, etc. Algorithms for approximate query answering and scalable data processing will be studied. The students will also have the opportunity to study platforms for managing big data, such as, map-reduce, platforms for data streams, and platforms for graph data.
Innehåll: A tentative list of topics includes: algorithms for query optimization, data warehousing and OLAP, approximate query answering, scalable data analysis, managing text data, managing web data, managing semi-structured data, distributed hash-tables, data cleaning, platforms for big data.
Metoder, arbetssätt och bedömningsgrunder: Take-home homeworks, programming assignments, and in-class final exam.
Studiematerial: Lecture slides and online lecture notes.
Ersättande prestationer: ICS-E5040 Modern Database Systems
Förkunskaper: Basics in mathematics and computer science. Knowledge of data structures.
Bedömningsskala: 0-5
Undervisningsspråk: English

CS-E4610 Modern Database Systems (5 cr)

Responsible teacher: Aristides Gionis
Level of the Course: Master's level
Teaching Period: III-IV
Workload: Lectures: 2h/week, Independent study: 2h/week, Homeworks: 4h/week, Projects: 20h total
Learning Outcomes: Upon completion of the course, the students should be able to understand and cope successfully with various aspects of data management in modern database systems. Emphasis will be given in managing data that have complex structure, such as, text data, web data, social data, etc. Algorithms for approximate query answering and scalable data processing will be studied. The students will also have the opportunity to study platforms for managing big data, such as, map-reduce, platforms for data streams, and platforms for graph data.
Content: A tentative list of topics includes: algorithms for query optimization, data warehousing and OLAP, approximate query answering, scalable data analysis, managing text data, managing web data, managing semi-structured data, distributed hash-tables, data cleaning, platforms for big data.
Assessment Methods and Criteria: Take-home homeworks, programming assignments, and in-class final exam.
Study Material: Lecture slides and online lecture notes.
Substitutes for Courses: ICS-E5040 Modern Database Systems
Prerequisites: Basics in mathematics and computer science. Knowledge of data structures.
Grading Scale: 0-5

Language of Instruction: English

CS-E4620 Introduction to Analytics and Data Science (2 cr)

Responsible teacher: Aristides Gionis
Status of the Course: Compulsory course of the Analytics and Data Science Minor.
Level of the Course: Master's level
Teaching period: I (Autumn)
Workload: There is no homework, but attendance is compulsory.
Content: The purpose of the course is to give a short introduction to the emerging area of analytics and data science. It serves the purpose of providing a short overview of he subareas and the topics covered in the "Analytics and Data Science" module. The course will be structured by guest lectures of the professors affiliated with the module.
Assessment Methods and Criteria: Passing the course will be based only on attendance.
Study Material: The slides used for presentation will become available.
Substitutes for Courses: ICS-E4010 Introduction to Analytics and Data Science
Evaluation: pass/fail
Language of Instruction: English

CS-E4620 Introduction to Analytics and Data Science (2 sp)

Ansvarig lärare: Aristides Gionis
Kursens status: Compulsory course of the Analytics and Data Science Minor.
Kursnivå: Master's level
Undervisningsperiod: I (Autumn)
Arbetsmängd: There is no homework, but attendance is compulsory.
Innehåll: The purpose of the course is to give a short introduction to the emerging area of analytics and data science. It serves the purpose of providing a short overview of he subareas and the topics covered in the "Analytics and Data Science" module. The course will be structured by guest lectures of the professors affiliated with the module.
Metoder, arbetssätt och bedömningsgrunder: Passing the course will be based only on attendance.
Studiematerial: The slides used for presentation will become available.
Ersättande prestationer: ICS-E4010 Introduction to Analytics and Data Science
Bedömningsskala: pass/fail
Undervisningsspråk: English

CS-E4620 Introduction to Analytics and Data Science (2 cr)

Responsible teacher: Aristides Gionis
Status of the Course: Compulsory course of the Analytics and Data Science Minor.
Level of the Course: Master's level
Teaching Period: I (Autumn)

Workload: There is no homework, but attendance is compulsory.
Content: The purpose of the course is to give a short introduction to the emerging area of analytics and data science. It serves the purpose of providing a short overview of he subareas and the topics covered in the “Analytics and Data Science” module. The course will be structured by guest lectures of the professors affiliated with the module.
Assessment Methods and Criteria: Passing the course will be based only on attendance.
Study Material: The slides used for presentation will become available.
Substitutes for Courses: ICS-E4010 Introduction to Analytics and Data Science
Grading Scale: pass/fail
Language of Instruction: English

CS-E4630 Hajautetut tietokannat (5 op)

Vastuuopettaja: Eljas Soisalon-Soininen
Kurssin taso: Kurssi on tarkoitettu kandidaatin tutkinnon suorittaneille.
Opetusperiodi: II
Työmäärä toteutustavoittain: Luento-opetus 21 h, pienryhmäopetus 12 h.
Osaamistavoitteet: Kurssin suoritettuasi ymmärrät hajautetun tietokantaratkaisun merkityksen ja sisällön keskitettyyn ratkaisuun verrattuna. Hallitset hajautettujen tietokantojen hallintajärjestelmien pääasialliset ratkaisumenetelmät. Osaat suunnitella yksinkertaisen hajautetun tietokantajärjestelmän.
Sisältö: Tiedon hajauttaminen ja hajautettu kyselynkäsittely. Hajautettujen transaktioiden hallinta. Toisinnetun tietokannan hallinta. Rinnakkaistietokannat. Sivupalvelin- ja yhteislevyjärjestelmät. Hajautettujen transaktioiden käsittelyjärjestelmät.
Toteutus, työmuodot ja arvosteluperusteet: Tentti.
Oppimateriaali: Opetusmoniste.
Korvaavuudet: Korvaa kurssin T-106.5241 / T-106.5240 Hajautetut tietokannat L.
Esitiedot: CS-E4230 /T-106.5221 Transaction Management in Databases
Arvosteluasteikko: 0-5
Opetuskieli: Suomi pääosin. Pyydettäessä suoritettavissa englanniksi.
Lisätietoja: Vapaaehtoiset harjoitustehtävät on mahdollista palauttaa englanniksi.

CS-E4630 Distribuerade databaser (5 sp)

Ansvarig lärare: Eljas Soisalon-Soininen
Kursnivå: Kursen är ämnad för studerande som avlagt kandidatexamen.
Undervisningsperiod: II
Arbetsmängd: Föreläsningar 21 h, undervisning i små grupper 12 h.
Lärandemål: Efter avklarad kurs förstår du betydelsen och innehållet av en distribuerad databas jämfört med en centraliserad sådan. Du behärskar de huvudsakliga lösningsmetoderna för distribuerade databaser. Du kan planera ett enkelt distribuerat databassystem.
Innehåll: Distribuering av data och distribuerad hantering av förfrågningar. Hantering av distribuerade transaktioner. Administration av dublikerade

databaser. Paralella databaser. “Pageserver” system och system med delade skivor. System för hantering av distribuerade transaktioner.
Metoder, arbetssätt och bedömningsgrunder: Tentamen.
Studiematerial: Kompendier.
Ersättande prestationer: Ersätter kursen T-106.5241 / T-106.5240 Distribuerade databaser L.
Förkunskaper: CS-E4230 /T-106.5221 Transaction Management in Databases
Bedömningsskala: 0-5
Undervisningsspråk: Huvudsakligen på finska. Kan på begäran avläggas på engelska.

CS-E4630 Distributed Databases (5 cr)

Responsible teacher: Eljas Soisalon-Soininen
Level of the Course: The course is only for students who have completed their Bachelor’s Degree.
Teaching Period: II
Workload: Lectures 21 h, teaching in small groups 12 h.
Learning Outcomes: After following the course, the student will appreciate the significance of a distributed database as compared to a centralized one and understand its main components. The student will be aware of the main techniques for managing a distributed database management system and be able to design a simple distributed database system.
Content: Data distribution and distributed query processing. Processing of distributed transactions. Management of a replicated database. Parallell databases. Page-server and shared-disks systems. Systems for processing distributed transactions.
Assessment Methods and Criteria: Examination.
Study Material: Lecture notes (in Finnish) with study-guides in English plus references to English-language texts.
Substitutes for Courses: Replaces the course T-106.5241 / T-106.5240 Distributed Databases L.
Prerequisites: CS-E4230 /T-106.5221 Transaction Management in Databases
Grading Scale: 0-5
Language of Instruction: Primarily Finnish. The assessed work may be completed in English upon request.
Further Information: The optional homework may be submitted in English.

CS-E4800 Artificial Intelligence (5 cr)

Responsible teacher: Tapani Raiko
Status of the Course: Optional course of the Game Design and Production major.
Level of the Course: Master’s level
Teaching period: III - IV (Spring)
Workload: Total 133 hours consisting of lectures (22 hours), exercise sessions (18 hours), examination (3 hours), independent study (31 hours), solving exercise problems (27 hours), and assignments (32 hours)
Learning Outcomes: After the course, the student has an understanding of the

main methods for problem solving, including search algorithms, reasoning and search with logical representations, and decision making under uncertainty. The student has experience in solving problems by writing declarative specifications in logical and state-based modeling languages and by finding solutions by existing tools that implement efficient search methods.
Content: The course covers some of the most important methods for building intelligent systems, with the focus in models and algorithms for automated decision-making, from deterministic single-agent problems with perfect information to general classes of problems with stochastic environments, imperfect information, and multiple agents, reinforcement learning, game–tree search, game theory, and the use of computational logic.
Assessment Methods and Criteria: Examination and term project(s)
Study Material: Russell and Norvig: Artificial Intelligence: A Modern Approach
Substitutes for Courses: ICS-E4000 Artificial Intelligence
Prerequisites: Programming skills (CS-A1110 / CSE-A1110, or the old versions T-106.1200/1203/1206/1207 or equivalent), data structures and algorithms (CS-A1140 / CSE-A1140 or equivalent), basics of probability theory (MS-A050* or equivalent). The prerequisite for the course is basics of propositional logic, taught in CS-E3200 / T-79.4101 Discrete Models and Search, which may be taken simultaneously with this course.
Evaluation: 0-5
Language of Instruction: English

CS-E4800 Artificial Intelligence (5 sp)

Ansvarig lärare: Tapani Raiko
Kursens status: Optional course of the Game Design and Production major.
Kursnivå: Master's level
Undervisningsperiod: III - IV (Spring)
Arbetsmängd: Total 133 hours consisting of lectures (22 hours), exercise sessions (18 hours), examination (3 hours), independent study (31 hours), solving exercise problems (27 hours), and assignments (32 hours)
Lärandemål: After the course, the student has an understanding of the main methods for problem solving, including search algorithms, reasoning and search with logical representations, and decision making under uncertainty. The student has experience in solving problems by writing declarative specifications in logical and state-based modeling languages and by finding solutions by existing tools that implement efficient search methods.
Innehåll: The course covers some of the most important methods for building intelligent systems, with the focus in models and algorithms for automated decision-making, from deterministic single-agent problems with perfect information to general classes of problems with stochastic environments, imperfect information, and multiple agents, reinforcement learning, game–tree search, game theory, and the use of computational logic.
Metoder, arbetssätt och bedömningsgrunder: Examination and term project(s)
Studiematerial: Russell and Norvig: Artificial Intelligence: A Modern Approach
Ersättande prestationer: ICS-E4000 Artificial Intelligence

Förkunskaper: Programming skills (CS-A1110 / CSE-A1110 or the old versions T-106.1200/1203/1206/1207 or equivalent), data structures and algorithms (CS-A1140 / CSE-A1140 or equivalent), basics of probability theory (MS-A050* or equivalent). The prerequisite for the course is basics of propositional logic, taught in CS-E3200 / T-79.4101 Discrete Models and Search, which may be taken simultaneously with this course.
Bedömningsskala: 0-5
Undervisningsspråk: English

CS-E4800 Artificial Intelligence (5 cr)

Responsible teacher: Tapani Raiko
Status of the Course: Optional course of the Game Design and Production major.
Level of the Course: Master's level
Teaching Period: III - IV (Spring)
Workload: Total 133 hours consisting of lectures (22 hours), exercise sessions (18 hours), examination (3 hours), independent study (31 hours), solving exercise problems (27 hours), and assignments (32 hours)
Learning Outcomes: After the course, the student has an understanding of the main methods for problem solving, including search algorithms, reasoning and search with logical representations, and decision making under uncertainty. The student has experience in solving problems by writing declarative specifications in logical and state-based modeling languages and by finding solutions by existing tools that implement efficient search methods.
Content: The course covers some of the most important methods for building intelligent systems, with the focus in models and algorithms for automated decision-making, from deterministic single-agent problems with perfect information to general classes of problems with stochastic environments, imperfect information, and multiple agents, reinforcement learning, game–tree search, game theory, and the use of computational logic.
Assessment Methods and Criteria: Examination and term project(s)
Study Material: Russell and Norvig: Artificial Intelligence: A Modern Approach
Substitutes for Courses: ICS-E4000 Artificial Intelligence
Prerequisites: Programming skills (CS-A1110 / CSE-A1110, or the old versions T-106.1200/1203/1206/1207 or equivalent), data structures and algorithms (CS-A1140 / CSE-A1140 or equivalent), basics of probability theory (MS-A050* or equivalent). The prerequisite for the course is basics of propositional logic, taught in CS-E3200 / T-79.4101 Discrete Models and Search, which may be taken simultaneously with this course.
Grading Scale: 0-5
Language of Instruction: English

CS-E4810 Machine Learning and Neural Networks (5 cr)

Responsible teacher: Juha Karhunen
Level of the Course: Master's level
Teaching period: II (Autumn)
Workload: 24 + 24 (4 + 4)

Learning Outcomes: Understanding of the general principles of neural networks, and the central neural network and machine learning methods discussed in the course. After the course, you should be able to apply them to real-world data sets.
Content: Introduction to neural networks, principal component analysis and data preprocessing, multilayer perceptron networks, extreme learning machine, model assessment and selection, radial-basis function networks, support vector machines, independent component analysis, self-organizing maps, temporal processing in neural networks, combining learners, and deep learning, as well as a few applications of these methods.
Assessment Methods and Criteria: Examination and computer assignment.
Study Material: Lecture slides and solutions of exercises are the central materials in this course. They are supported with texts taken from different sources. The book K.-L. Du and M. Swamy, "Neural Networks and Statistical Learning", Springer 2014, is used as a reference in many lectures.
Substitutes for Courses: T-61.5130 Machine Learning and Neural Networks
Prerequisites: Basic courses in mathematics and probability. The course CS-E3210 / T-61.3050 Machine Learning: Basic Principles is recommended as a prerequisite but this course can be taken without it.
Evaluation: 0-5
Language of Instruction: English

CS-E4810 Machine Learning and Neural Networks (5 sp)

Ansvarig lärare: Juha Karhunen
Kursnivå: Master's level
Undervisningsperiod: II (Autumn)
Arbetsmängd: 24 + 24 (4 + 4)
Lärandemål: Understanding of the general principles of neural networks, and the central neural network and machine learning methods discussed in the course. After the course, you should be able to apply them to real-world data sets.
Innehåll: Introduction to neural networks, principal component analysis and data preprocessing, multilayer perceptron networks, extreme learning machine, model assessment and selection, radial-basis function networks, support vector machines, independent component analysis, self-organizing maps, temporal processing in neural networks, combining learners, and deep learning, as well as a few applications of these methods.
Metoder, arbetssätt och bedömningsgrunder: Examination and computer assignment.
Studiematerial: Lecture slides and solutions of exercises are the central materials in this course. They are supported with texts taken from different sources. The book K.-L. Du and M. Swamy, "Neural Networks and Statistical Learning", Springer 2014, is used as a reference in many lectures.
Ersättande prestationer: T-61.5130 Machine Learning and Neural Networks
Förkunskaper: Basic courses in mathematics and probability. The course CS-E3210 / T-61.3050 Machine Learning: Basic Principles is recommended as a prerequisite but this course can be taken without it.
Bedömningsskala: 0-5

Undervisningsspråk: English

CS-E4810 Machine Learning and Neural Networks (5 cr)

Responsible teacher: Juha Karhunen
Level of the Course: Master's level
Teaching Period: II (Autumn)
Workload: 24 + 24 (4 + 4)
Learning Outcomes: Understanding of the general principles of neural networks, and the central neural network and machine learning methods discussed in the course. After the course, you should be able to apply them to real-world data sets.
Content: Introduction to neural networks, principal component analysis and data preprocessing, multilayer perceptron networks, extreme learning machine, model assessment and selection, radial-basis function networks, support vector machines, independent component analysis, self-organizing maps, temporal processing in neural networks, combining learners, and deep learning, as well as a few applications of these methods.
Assessment Methods and Criteria: Examination and computer assignment.
Study Material: Lecture slides and solutions of exercises are the central materials in this course. They are supported with texts taken from different sources. The book K.-L. Du and M. Swamy, "Neural Networks and Statistical Learning", Springer 2014, is used as a reference in many lectures.
Substitutes for Courses: T-61.5130 Machine Learning and Neural Networks
Prerequisites: Basic courses in mathematics and probability. The course CS-E3210 / T-61.3050 Machine Learning: Basic Principles is recommended as a prerequisite but this course can be taken without it.
Grading Scale: 0-5
Language of Instruction: English

CS-E4820 Machine Learning: Advanced Probabilistic Methods (5 cr)

Responsible teacher: Pekka Marttinen
Level of the Course: Master's level
Teaching period: III - IV (Spring)
Workload: 24 + 24 (2 + 2)
Learning Outcomes: After the course, the student understands how Bayesian networks are constructed with conditional independence assumptions and how they are applied in modeling of joint probability distributions. The students can explain the structure and usage of common probabilistic models in machine learning, such as Gaussian mixture models and factor analysis models. The students can apply Bayes' theorem for computing probability statements and understand the fundamental role of Bayes' theorem in probabilistic inference. The coupling of inference and learning is understood in the context of latent variable models and the EM algorithm. Student knows approximate inference and sampling techniques for complex models, where exact probabilistic inference can not be applied. Furthermore, they can translate probabilistic models, inference and learning algorithms into practical computer implementations.
Content: The course covers probabilistic concepts in machine learning:

independece, conditional independence, mixture models, EM algorithm, Bayesian networks, computational algorithms for exact and approximate inference, sampling, prior distributions. The course emphasizes understanding fundamental principles and their use in practical machine learning problems.
Assessment Methods and Criteria: Combination of exercises, project, and exam (details are provided on the first lecture).
Study Material: David Barber, Bayesian Reasoning and Machine Learning. Cambridge University Press, 2012.
Substitutes for Courses: Replaces the former course T-61.5140 Machine Learning: Advanced Probabilistic Methods and T-61.5040 Learning Models and Methods.
Prerequisites: CS-E3210 / T-61.3050 Machine Learning: Basic Principles
Evaluation: 0-5
Language of Instruction: English

CS-E4820 Machine Learning: Advanced Probabilistic Methods (5 sp)

Ansvarig lärare: Pekka Marttinen
Kursnivå: Master's level
Undervisningsperiod: III - IV (Spring)
Arbetsmängd: 24 + 24 (2 + 2)
Lärandemål: After the course, the student understands how Bayesian networks are constructed with conditional independence assumptions and how they are applied in modeling of joint probability distributions. The students can explain the structure and usage of common probabilistic models in machine learning, such as Gaussian mixture models and factor analysis models. The students can apply Bayes' theorem for computing probability statements and understand the fundamental role of Bayes' theorem in probabilistic inference. The coupling of inference and learning is understood in the context of latent variable models and the EM algorithm. Student knows approximate inference and sampling techniques for complex models, where exact probabilistic inference can not be applied. Furthermore, they can translate probabilistic models, inference and learning algorithms into practical computer implementations.
Innehåll: The course covers probabilistic concepts in machine learning: independece, conditional independence, mixture models, EM algorithm, Bayesian networks, computational algorithms for exact and approximate inference, sampling, prior distributions. The course emphasizes understanding fundamental principles and their use in practical machine learning problems.
Metoder, arbetssätt och bedömningsgrunder: Combination of exercises, project, and exam (details are provided on the first lecture).
Studiematerial: David Barber, Bayesian Reasoning and Machine Learning. Cambridge University Press, 2012.
Ersättande prestationer: Replaces the former course T-61.5140 Machine Learning: Advanced Probabilistic Methods and T-61.5040 Learning Models and Methods.
Förkunskaper: CS-E3210 / T-61.3050 Machine Learning: Basic Principles
Bedömningsskala: 0-5

Undervisningsspråk: English

CS-E4820 Machine Learning: Advanced Probabilistic Methods (5 cr)

Responsible teacher: Pekka Marttinen
Level of the Course: Master's level
Teaching Period: III - IV (Spring)
Workload: 24 + 24 (2 + 2)
Learning Outcomes: After the course, the student understands how Bayesian networks are constructed with conditional independence assumptions and how they are applied in modeling of joint probability distributions. The students can explain the structure and usage of common probabilistic models in machine learning, such as Gaussian mixture models and factor analysis models. The students can apply Bayes' theorem for computing probability statements and understand the fundamental role of Bayes' theorem in probabilistic inference. The coupling of inference and learning is understood in the context of latent variable models and the EM algorithm. Student knows approximate inference and sampling techniques for complex models, where exact probabilistic inference can not be applied. Furthermore, they can translate probabilistic models, inference and learning algorithms into practical computer implementations.
Content: The course covers probabilistic concepts in machine learning: independece, conditional independence, mixture models, EM algorithm, Bayesian networks, computational algorithms for exact and approximate inference, sampling, prior distributions. The course emphasizes understanding fundamental principles and their use in practical machine learning problems.
Assessment Methods and Criteria: Combination of exercises, project, and exam (details are provided on the first lecture).
Study Material: David Barber, Bayesian Reasoning and Machine Learning. Cambridge University Press, 2012.
Substitutes for Courses: Replaces the former course T-61.5140 Machine Learning: Advanced Probabilistic Methods and T-61.5040 Learning Models and Methods.
Prerequisites: CS-E3210 / T-61.3050 Machine Learning: Basic Principles
Grading Scale: 0-5
Language of Instruction: English

CS-E4830 Kernel Methods in Machine Learning (5 cr)

Responsible teacher: Juho Rousu
Level of the Course: Master's level
Teaching period: I-II (Autumn)
Workload: Lectures and exercises
Learning Outcomes: After attending the course, the student knows how kernel methods can be used in various machine learning tasks, including classification, ranking and preference learning, as well as learning with multiple data sources and targets. The student knows how convex optimization methods can be used to efficiently train kernel-based models. The student knows how structured data such as sequences, hierarchies and graphs can be tackled through kernel methods.

Content: Margin-based models and kernels. Classification and Support vector machines. Ranking and preference learning. Unsupervised learning with kernels. Kernels for structured data. Multilabel classification. Semi-supervised learning. Predicting structured output. Convex optimization methods.
Assessment Methods and Criteria: Exercises and exam.
Study Material: Shawe-Taylor and Cristianini: Kernel Methods for Pattern Analysis, Cambridge University Press, 2004. Slides and research papers provided during the course.
Substitutes for Courses: ICS-E4030 Kernel Methods in Machine Learning
Prerequisites: Bachelor's degree in computer science and the course CS-E3210 / T-61.3050 Machine Learning: Basic principles (or equivalent knowledge).
Evaluation: 0-5
Language of Instruction: English

CS-E4830 Kernel Methods in Machine Learning (5 sp)

Ansvarig lärare: Juho Rousu
Kursnivå: Master's level
Undervisningsperiod: I-II (Autumn)
Arbetsmängd: Lectures and exercises
Lärandemål: After attending the course, the student knows how kernel methods can be used in various machine learning tasks, including classification, ranking and preference learning, as well as learning with multiple data sources and targets. The student knows how convex optimization methods can be used to efficiently train kernel-based models. The student knows how structured data such as sequences, hierarchies and graphs can be tackled through kernel methods.
Innehåll: Margin-based models and kernels. Classification and Support vector machines. Ranking and preference learning. Unsupervised learning with kernels. Kernels for structured data. Multilabel classification. Semi-supervised learning. Predicting structured output. Convex optimization methods.
Metoder, arbetssätt och bedömningsgrunder: Exercises and exam.
Studiematerial: Shawe-Taylor and Cristianini: Kernel Methods for Pattern Analysis, Cambridge University Press, 2004. Slides and research papers provided during the course.
Ersättande prestationer: ICS-E4030 Kernel Methods in Machine Learning
Förkunskaper: Bachelor's degree in computer science and the course CS-E3210 / T-61.3050 Machine Learning: Basic principles (or equivalent knowledge).
Bedömningsskala: 0-5
Undervisningsspråk: English

CS-E4830 Kernel Methods in Machine Learning (5 cr)

Responsible teacher: Juho Rousu
Level of the Course: Master's level
Teaching Period: I-II (Autumn)
Workload: Lectures and exercises
Learning Outcomes: After attending the course, the student knows how kernel methods can be used in various machine learning tasks, including classification,

ranking and preference learning, as well as learning with multiple data sources and targets. The student knows how convex optimization methods can be used to efficiently train kernel-based models. The student knows how structured data such as sequences, hierarchies and graphs can be tackled through kernel methods.
Content: Margin-based models and kernels. Classification and Support vector machines. Ranking and preference learning. Unsupervised learning with kernels. Kernels for structured data. Multilabel classification. Semi-supervised learning. Predicting structured output. Convex optimization methods.
Assessment Methods and Criteria: Exercises and exam.
Study Material: Shawe-Taylor and Cristianini: Kernel Methods for Pattern Analysis, Cambridge University Press, 2004. Slides and research papers provided during the course.
Substitutes for Courses: ICS-E4030 Kernel Methods in Machine Learning
Prerequisites: Bachelor's degree in computer science and the course CS-E3210 / T-61.3050 Machine Learning: Basic principles (or equivalent knowledge).
Grading Scale: 0-5
Language of Instruction: English

CS-E4840 Information Visualization (5 cr)

Responsible teacher: Aristides Gionis
Level of the Course: Master's level
Teaching period: IV
Workload: 24 + 12 (4 + 2)
Learning Outcomes: Information visualization offers instruments for reasoning about quantitative information, analyzing and communicating statistical information. The course overviews the main typologies of data graphics (data-maps, time-series, space-time narrative, relational diagrams, graphs and methods for dimensionality reduction) and provides a language for discussing data visualizations combined with a knowledge of the human perception of visual objects.
Content: The course teaches how to visualize information effectively by using the statistical methods, combined with knowledge of the human perception and the basics of data graphics.
Assessment Methods and Criteria: Examination and exercise work.
Study Material: Lecture notes, and E. Tufte, The Visual Display of Quantitative Information, Graphics Press, 1983, and C. Ware, Information Visualization - Perception for Design, Morgan Kaufmann, 2004.
Substitutes for Courses: T-61.5010 Information Visualization
Prerequisites: Basic mathematics courses.
Evaluation: 0-5
Language of Instruction: English

CS-E4840 Information Visualization (5 sp)

Ansvarig lärare: Aristides Gionis
Kursnivå: Master's level
Undervisningsperiod: IV

Arbetsmängd: 24 + 12 (4 + 2)
Lärandemål: Information visualization offers instruments for reasoning about quantitative information, analyzing and communicating statistical information. The course overviews the main typologies of data graphics (data-maps, time-series, space-time narrative, relational diagrams, graphs and methods for dimensionality reduction) and provides a language for discussing data visualizations combined with a knowledge of the human perception of visual objects.
Innehåll: The course teaches how to visualize information effectively by using the statistical methods, combined with knowledge of the human perception and the basics of data graphics.
Metoder, arbetssätt och bedömningsgrunder: Examination and exercise work.
Studiematerial: Lecture notes, and E. Tufte, The Visual Display of Quantitative Information, Graphics Press, 1983, and C. Ware, Information Visualization - Perception for Design, Morgan Kaufmann, 2004.
Ersättande prestationer: T-61.5010 Information Visualization
Förkunskaper: Basic mathematics courses.
Bedömningsskala: 0-5
Undervisningsspråk: English

CS-E4840 Information Visualization (5 cr)

Responsible teacher: Aristides Gionis
Level of the Course: Master's level
Teaching Period: IV
Workload: 24 + 12 (4 + 2)
Learning Outcomes: Information visualization offers instruments for reasoning about quantitative information, analyzing and communicating statistical information. The course overviews the main typologies of data graphics (data-maps, time-series, space-time narrative, relational diagrams, graphs and methods for dimensionality reduction) and provides a language for discussing data visualizations combined with a knowledge of the human perception of visual objects.
Content: The course teaches how to visualize information effectively by using the statistical methods, combined with knowledge of the human perception and the basics of data graphics.
Assessment Methods and Criteria: Examination and exercise work.
Study Material: Lecture notes, and E. Tufte, The Visual Display of Quantitative Information, Graphics Press, 1983, and C. Ware, Information Visualization - Perception for Design, Morgan Kaufmann, 2004.
Substitutes for Courses: T-61.5010 Information Visualization
Prerequisites: Basic mathematics courses.
Grading Scale: 0-5
Language of Instruction: English

CS-E4850 Computer Vision (5 cr)

Responsible teacher: Juho Kannala

Level of the Course: Master (suitable for 1st year Master students)
Teaching period: III - IV (Spring)
Workload: 24 + 24 (2 + 2) and project work
Learning Outcomes: After the course, the student is familiar with basic concepts and methods of computer vision. The student understands the basic principles of image-based 3D reconstruction and is familiar with techniques used for automatic object recognition from images. The student can design and implement common computer vision methods and apply them to practical problems with real-world image data.
Content: Image formation and processing, feature detection and matching, motion estimation, structure-from-motion, object recognition, image-based 3D reconstruction. The course gives an overview of algorithms, models and methods, which are used in automatic analysis of visual data.
Assessment Methods and Criteria: Combination of exercises, project and exam (details are provided on the first lecture).
Study Material:
R. Szeliski. Computer Vision: Algorithms and Applications (http://szeliski.org/Book/)
Substitutes for Courses: T-61.5070 Computer Vision
Prerequisites: Basic mathematics courses.
Evaluation: 0-5
Language of Instruction: English

CS-E4850 Computer Vision (5 sp)

Ansvarig lärare: Juho Kannala
Kursnivå: Master (suitable for 1st year Master students)
Undervisningsperiod: III - IV (Spring)
Arbetsmängd: 24 + 24 (2 + 2) and project work
Lärandemål: After the course, the student is familiar with basic concepts and methods of computer vision. The student understands the basic principles of image-based 3D reconstruction and is familiar with techniques used for automatic object recognition from images. The student can design and implement common computer vision methods and apply them to practical problems with real-world image data.
Innehåll: Image formation and processing, feature detection and matching, motion estimation, structure-from-motion, object recognition, image-based 3D reconstruction. The course gives an overview of algorithms, models and methods, which are used in automatic analysis of visual data.
Metoder, arbetssätt och bedömningsgrunder: Combination of exercises, project and exam (details are provided on the first lecture).
Studiematerial: R. Szeliski. Computer Vision: Algorithms and Applications (http://szeliski.org/Book/)
Ersättande prestationer: T-61.5070 Computer Vision
Förkunskaper: Basic mathematics courses.
Bedömningsskala: 0-5
Undervisningsspråk: English

CS-E4850 Computer Vision (5 cr)

Responsible teacher: Juho Kannala
Level of the Course: Master (suitable for 1st year Master students)
Teaching Period: III - IV (Spring)
Workload: 24 + 24 (2 + 2) and project work
Learning Outcomes: After the course, the student is familiar with basic concepts and methods of computer vision. The student understands the basic principles of image-based 3D reconstruction and is familiar with techniques used for automatic object recognition from images. The student can design and implement common computer vision methods and apply them to practical problems with real-world image data.
Content: Image formation and processing, feature detection and matching, motion estimation, structure-from-motion, object recognition, image-based 3D reconstruction. The course gives an overview of algorithms, models and methods, which are used in automatic analysis of visual data.
Assessment Methods and Criteria: Combination of exercises, project and exam (details are provided on the first lecture).
Study Material: R. Szeliski. Computer Vision: Algorithms and Applications (http://szeliski.org/Book/)
Substitutes for Courses: T-61.5070 Computer Vision
Prerequisites: Basic mathematics courses.
Grading Scale: 0-5
Language of Instruction: English

CS-E4860 Special Course in Bioinformatics II(V) (3-10 cr)

Responsible teacher: Juho Rousu
Teaching period: IV - V (Spring)
Workload: Seminar paper and presentation, may include a small project.
Learning Outcomes: To be specified in MyCourses at the start of the course.
Content: Postgraduate level knowledge from one of the fields of bioinformatics. The actual contents of the course vary from year to year. The course can be lectured, or arranged in seminar form.
Assessment Methods and Criteria: To be specified in MyCourses at the start of the course.
Study Material: Usually a collection of articles.
Substitutes for Courses: T-61.6080 Special Course in Bioinformatics II
Evaluation: 0-5, may be graded with pass/fail
Language of Instruction: English
Further Information: The content of the course varies.

CS-E4860 Special Course in Bioinformatics II(V) (3-10 sp)

Ansvarig lärare: Juho Rousu
Undervisningsperiod: IV - V (Spring)
Arbetsmängd: Seminar paper and presentation, may include a small project.

Lärandemål: To be specified in MyCourses at the start of the course.
Innehåll: Postgraduate level knowledge from one of the fields of bioinformatics. The actual contents of the course vary from year to year. The course can be lectured, or arranged in seminar form.
Metoder, arbetssätt och bedömningsgrunder: To be specified in MyCourses at the start of the course.
Studiematerial: Usually a collection of articles.
Ersättande prestationer: T-61.6080 Special Course in Bioinformatics II
Bedömningsskala: 0-5, may be graded with pass/fail
Undervisningsspråk: English
Tilläggsinformation: The content of the course varies.

CS-E4860 Special Course in Bioinformatics II(V) (3-10 cr)

Responsible teacher: Juho Rousu
Teaching Period: IV - V (Spring)
Workload: Seminar paper and presentation, may include a small project.
Learning Outcomes: To be specified in MyCourses at the start of the course.
Content: Postgraduate level knowledge from one of the fields of bioinformatics. The actual contents of the course vary from year to year. The course can be lectured, or arranged in seminar form.
Assessment Methods and Criteria: To be specified in MyCourses at the start of the course.
Study Material: Usually a collection of articles.
Substitutes for Courses: T-61.6080 Special Course in Bioinformatics II
Grading Scale: 0-5, may be graded with pass/fail
Language of Instruction: English
Further Information: The content of the course varies.

CS-E4870 Research Project in Machine Learning and Data Science (10 cr)

Responsible teacher: Aristides Gionis
Teaching period: I - II (Autumn)
Workload: Seminars. Independent or group work (discussions with supervisor, programming, reporting, preparation of presentation).
Learning Outcomes: After the course, the student knows how to carry out a scientific project and write a scientific report in the field of computer and information science.
Content: A project work, which can be done in a group, from the field of computer and information science.
Assessment Methods and Criteria: Report and presentation. The course grade is determined by the report (100%).
Substitutes for Courses: T-61.5910 Research Project in Computer and Information Science
Evaluation: 0-5
Language of Instruction: English

CS-E4870 Research Project in Machine Learning and Data Science (10 sp)

Ansvarig lärare: Aristides Gionis
Undervisningsperiod: I - II (Autumn)
Arbetsmängd: Seminars. Independent or group work (discussions with supervisor, programming, reporting, preparation of presentation).
Lärandemål: After the course, the student knows how to carry out a scientific project and write a scientific report in the field of computer and information science.
Innehåll: A project work, which can be done in a group, from the field of computer and information science.
Metoder, arbetssätt och bedömningsgrunder: Report and presentation. The course grade is determined by the report (100%).
Ersättande prestationer: T-61.5910 Research Project in Computer and Information Science
Bedömningsskala: 0-5
Undervisningsspråk: English

CS-E4870 Research Project in Machine Learning and Data Science (10 cr)

Responsible teacher: Aristides Gionis
Teaching Period: I - II (Autumn)
Workload: Seminars. Independent or group work (discussions with supervisor, programming, reporting, preparation of presentation).
Learning Outcomes: After the course, the student knows how to carry out a scientific project and write a scientific report in the field of computer and information science.
Content: A project work, which can be done in a group, from the field of computer and information science.
Assessment Methods and Criteria: Report and presentation. The course grade is determined by the report (100%).
Substitutes for Courses: T-61.5910 Research Project in Computer and Information Science
Grading Scale: 0-5
Language of Instruction: English

CS-E4900 User-Centered Methods for Product and Service Design (5 cr)

Responsible teacher: Marko Nieminen; Carl Mitts
Status of the Course: Compulsory course of the Software and Service Engineering major (UCD & SDE tracks), Information networks major (UCD track), ICT Innovation major (HCID track) and Usability School minor.
Level of the Course: Master's level
Teaching period: I – II (Autumn)
Workload: Lectures 16h (8x2h), workshops 4h, reading study materials 10h, writing assignment 20h, peer-review 10h, group work 70h and pitching 5h.
Learning Outcomes: After the course, you know the basic methods for user research.
You understand and can describe different methods for use in the beginning of the user-centered design process and select appropriate methods for a given user

research problem. You know how to apply a number of methods in a simple user research case.
You will be able to find and analyze relevant new information in the field and concisely present research results to an audience. You are comfortable with reading academic articles and will be able to write and reference an academically paper properly.
Content: The course introduces the commonly used user-centred user research methods for early stage product and service design, and provides tools to analyze and visualize the gathered data to fuel product and service design.
Assessment Methods and Criteria: Peer-reviewed essay (50%) and group work & pitching (50%).
Study Material: Lecture materials, selected journal and practitioner articles and complementary materials. Materials are announced in course web site.
Substitutes for Courses: Substitutes the former course CSE-E5800 User-Centered Methods for Product and Service Design and T-121.5151 Methods for User-Centred Product Development.
Prerequisites: CS-C3120 Human-Computer Interaction / CSE-C3800 User Interfaces and Usability or equivalent basics in user-centred design and usability.
Evaluation: 0-5, may be graded with pass/fail
Registration for Courses: Enrollment in WebOodi.
Language of Instruction: English
Further Information:
The number of participants will be limited (60). Registrations will be prioritized in the following order:
1) The students that have the course as a mandatory part in SSE, Information Networks, ICT Innovation, and uSchool majors,
2) The students that have the course as a mandatory part in SSE, Information Networks, ICT Innovation, and uSchool minors,
3) The students that have the course as an elective part of their major,
4) The students that have the course as an elective part of their minor, and
5) All other students based on registration order.

CS-E4900 User-Centered Methods for Product and Service Design (5 sp)

Ansvarig lärare: Marko Nieminen; Carl Mitts
Kursens status: Compulsory course of the Software and Service Engineering major (UCD & SDE tracks), Information networks major (UCD track), ICT Innovation major (HCID track) and Usability School minor.
Kursnivå: Master's level
Undervisningsperiod: I – II (Autumn)
Arbetsmängd: Lectures 16h (8x2h), workshops 4h, reading study materials 10h, writing assignment 20h, peer-review 10h, group work 70h and pitching 5h.
Lärandemål: After the course, you know the basic methods for user research. You understand and can describe different methods for use in the beginning of the user-centered design process and select appropriate methods for a given user research problem. You know how to apply a number of methods in a simple user research case.

You will be able to find and analyze relevant new information in the field and concisely present research results to an audience. You are comfortable with reading academic articles and will be able to write and reference an academically paper properly.
Innehåll: The course introduces the commonly used user-centred user research methods for early stage product and service design, and provides tools to analyze and visualize the gathered data to fuel product and service design.
Metoder, arbetssätt och bedömningsgrunder: Peer-reviewed essay (50%) and group work & pitching (50%).
Studiematerial: Lecture materials, selected journal and practitioner articles and complementary materials. Materials are announced in course web site.
Ersättande prestationer: Substitutes the former course CSE-E5800 User-Centered Methods for Product and Service Design and T-121.5151 Methods for User-Centred Product Development.
Förkunskaper: CS-C3120 Human-Computer Interaction / CSE-C3800 User Interfaces and Usability or equivalent basics in user-centred design and usability.
Bedömningsskala: 0-5, may be graded with pass/fail
Anmälning: Enrollment in WebOodi.
Undervisningsspråk: English
Tilläggsinformation:
The number of participants will be limited (60). Registrations will be prioritized in the following order:
1) The students that have the course as a mandatory part in SSE, Information Networks, ICT Innovation, and uSchool majors,
2) The students that have the course as a mandatory part in SSE, Information Networks, ICT Innovation, and uSchool minors,
3) The students that have the course as an elective part of their major,
4) The students that have the course as an elective part of their minor, and
5) All other students based on registration order.

CS-E4900 User-Centered Methods for Product and Service Design (5 cr)

Responsible teacher: Marko Nieminen; Carl Mitts
Status of the Course: Compulsory course of the Software and Service Engineering major (UCD & SDE tracks), Information networks major (UCD track), ICT Innovation major (HCID track) and Usability School minor.
Level of the Course: Master's level
Teaching Period: I – II (Autumn)
Workload: Lectures 16h (8x2h), workshops 4h, reading study materials 10h, writing assignment 20h, peer-review 10h, group work 70h and pitching 5h.
Learning Outcomes: After the course, you know the basic methods for user research.
You understand and can describe different methods for use in the beginning of the user-centered design process and select appropriate methods for a given user research problem. You know how to apply a number of methods in a simple user research case.
You will be able to find and analyze relevant new information in the field and

concisely present research results to an audience. You are comfortable with reading academic articles and will be able to write and reference an academically paper properly.
Content: The course introduces the commonly used user-centred user research methods for early stage product and service design, and provides tools to analyze and visualize the gathered data to fuel product and service design.
Assessment Methods and Criteria: Peer-reviewed essay (50%) and group work & pitching (50%).
Study Material: Lecture materials, selected journal and practitioner articles and complementary materials. Materials are announced in course web site.
Substitutes for Courses: Substitutes the former course CSE-E5800 User-Centered Methods for Product and Service Design and T-121.5151 Methods for User-Centred Product Development.
Prerequisites: CS-C3120 Human-Computer Interaction / CSE-C3800 User Interfaces and Usability or equivalent basics in user-centred design and usability.
Grading Scale: 0-5, may be graded with pass/fail
Registration for Courses: Enrollment in WebOodi.
Language of Instruction: English
Further Information:
The number of participants will be limited (60). Registrations will be prioritized in the following order:
1) The students that have the course as a mandatory part in SSE, Information Networks, ICT Innovation, and uSchool majors,
2) The students that have the course as a mandatory part in SSE, Information Networks, ICT Innovation, and uSchool minors,
3) The students that have the course as an elective part of their major,
4) The students that have the course as an elective part of their minor, and
5) All other students based on registration order.

CS-E4910 Software Project 3 (5-8 cr)

Responsible teacher: Jari Vanhanen; Casper Lassenius
Status of the Course: Compulsory course of the Software Engineering track in the Software and Service Engineering major.
Level of the Course: Master's level
Teaching period: I-V (Autumn & Spring)
Workload: Lectures 15h (period I only), project work 25h * (credits – 1)
Learning Outcomes: You learn to act as a Scrum Master in a software project.
Content: The course consists of a software development project which will be done for a real client from industry or academia. The projects use the Scrum framework which is presented in the lectures before the project. The activities include project management, requirements specification, design, coding, quality assurance, and system delivery. You will work as a Scrum Master in a project team whose developers are students from the CS-C2130 & CS-C2140 Software Project 1&2 courses.
Assessment Methods and Criteria: Project work.
Substitutes for Courses: Substitutes former courses CSE-E5600 Software

Project 3 and T-76.5115 Software Development Project II (6-8 cr).
Prerequisites: Mandatory Prerequisites: CS-C2130 & CS-C2140 Software Project 1 & 2, CS-C3150 Software Engineering Recommended Prerequisites: CS-C3180 Software Design and Modelling, CS-E4930 Software Processes and Projects / CSE-E4600 Software Project Management, CS-E4940 Requirements Engineering, T-76.5613 Software Testing and Quality Assurance
Evaluation: 0-5
Registration for Courses: Registration via WebOodi. Please see WebOodi for registration dates.
Language of Instruction: Finnish and English.

CS-E4910 Software Project 3 (5-8 sp)

Ansvarig lärare: Jari Vanhanen; Casper Lassenius
Kursens status: Compulsory course of the Software Engineering track in the Software and Service Engineering major.
Kursnivå: Master's level
Undervisningsperiod: I-V (Autumn & Spring)
Arbetsmängd: Lectures 15h (period I only), project work 25h * (credits – 1)
Lärandemål: You learn to act as a Scrum Master in a software project.
Innehåll: The course consists of a software development project which will be done for a real client from industry or academia. The projects use the Scrum framework which is presented in the lectures before the project. The activities include project management, requirements specification, design, coding, quality assurance, and system delivery. You will work as a Scrum Master in a project team whose developers are students from the CS-C2130 & CS-C2140 Software Project 1&2 courses.
Metoder, arbetssätt och bedömningsgrunder: Project work.
Ersättande prestationer: Substitutes former courses CSE-E5600 Software Project 3 and T-76.5115 Software Development Project II (6-8 cr).
Förkunskaper: Mandatory Prerequisites: CS-C2130 & CS-C2140 Software Project 1 & 2, CS-C3150 Software Engineering Recommended Prerequisites: CS-C3180 Software Design and Modelling, CS-E4930 Software Processes and Projects / CSE-E4600 Software Project Management, CS-E4940 Requirements Engineering, T-76.5613 Software Testing and Quality Assurance
Bedömningsskala: 0-5
Anmälning: Registration via WebOodi. Please see WebOodi for registration dates.
Undervisningsspråk: Finnish and English.

CS-E4910 Software Project 3 (5-8 cr)

Responsible teacher: Jari Vanhanen; Casper Lassenius
Status of the Course: Compulsory course of the Software Engineering track in the Software and Service Engineering major.
Level of the Course: Master's level
Teaching Period: I-V (Autumn & Spring)
Workload: Lectures 15h (period I only), project work 25h * (credits – 1)

Learning Outcomes: You learn to act as a Scrum Master in a software project.
Content: The course consists of a software development project which will be done for a real client from industry or academia. The projects use the Scrum framework which is presented in the lectures before the project. The activities include project management, requirements specification, design, coding, quality assurance, and system delivery. You will work as a Scrum Master in a project team whose developers are students from the CS-C2130 & CS-C2140 Software Project 1&2 courses.
Assessment Methods and Criteria: Project work.
Substitutes for Courses: Substitutes former courses CSE-E5600 Software Project 3 and T-76.5115 Software Development Project II (6-8 cr).
Prerequisites: Mandatory Prerequisites: CS-C2130 & CS-C2140 Software Project 1 & 2, CS-C3150 Software Engineering Recommended Prerequisites: CS-C3180 Software Design and Modelling, CS-E4930 Software Processes and Projects / CSE-E4600 Software Project Management, CS-E4940 Requirements Engineering, T-76.5613 Software Testing and Quality Assurance
Grading Scale: 0-5
Registration for Courses: Registration via WebOodi. Please see WebOodi for registration dates.
Language of Instruction: Finnish and English.

CS-E4920 Portfolio in Software and Service Engineering (1-5 cr)

Responsible teacher: Jari Vanhanen; Marjo Kauppinen
Level of the Course: Master's level
Teaching period: I, III, V (separate iterations in each).
Workload: Each iteration yields one credit and includes 6-12 hours of contact sessions and 10-20 hours of individual or group work.
Learning Outcomes: After taking this course, you are able to plan your studies in Software and Service Engineering major; analyze what you have learned from the courses and work experience so far; and create a learning portfolio. In addition, you are able to recognize your professional identity and network with other students in the Software and Service Engineering major.
Content: Reflection and planning of the studies in Software and Service Engineering major. Reflection and analysis of the professional identity and work experience.
Assessment Methods and Criteria: Study plan and learning portfolio; details vary between each iteration.
Study Material: To be announced later.
Substitutes for Courses: CSE-E5695 Portfolio in Software and Service Engineering
Prerequisites: This course is meant only for the students in Software and Service Engineering major.
Evaluation: pass/fail
Registration for Courses: Registration via WebOodi.
Language of Instruction: English
Further Information: The course is modular: the student can participate in

separate 1 cr iterations to accumulate up to 5 credits. The course takes place in three iterations: one in the beginning of period I, one in the beginning of period III; and one in the end of period V.
The course is highly recommended to be started in the first period I of the major studies. However, students in any phases of their major studies are welcome to participate the course. Please see the course home page for further information. Only for students in the Software and Service Engineering major.

CS-E4920 Portfolio in Software and Service Engineering (1-5 sp)

Ansvarig lärare: Jari Vanhanen; Marjo Kauppinen
Kursnivå: Master's level
Undervisningsperiod: I, III, V (separate iterations in each).
Arbetsmängd: Each iteration yields one credit and includes 6-12 hours of contact sessions and 10-20 hours of individual or group work.
Lärandemål: After taking this course, you are able to plan your studies in Software and Service Engineering major; analyze what you have learned from the courses and work experience so far; and create a learning portfolio. In addition, you are able to recognize your professional identity and network with other students in the Software and Service Engineering major.
Innehåll: Reflection and planning of the studies in Software and Service Engineering major. Reflection and analysis of the professional identity and work experience.
Metoder, arbetssätt och bedömningsgrunder: Study plan and learning portfolio; details vary between each iteration.
Studiematerial: To be announced later.
Ersättande prestationer: CSE-E5695 Portfolio in Software and Service Engineering
Förkunskaper: This course is meant only for the students in Software and Service Engineering major.
Bedömningsskala: pass/fail
Anmälning: Registration via WebOodi.
Undervisningsspråk: English
Tilläggsinformation: The course is modular: the student can participate in separate 1 cr iterations to accumulate up to 5 credits. The course takes place in three iterations: one in the beginning of period I, one in the beginning of period III; and one in the end of period V.
The course is highly recommended to be started in the first period I of the major studies. However, students in any phases of their major studies are welcome to participate the course. Please see the course home page for further information. Only for students in the Software and Service Engineering major.

CS-E4920 Portfolio in Software and Service Engineering (1-5 cr)

Responsible teacher: Jari Vanhanen; Marjo Kauppinen
Level of the Course: Master's level
Teaching Period: I, III, V (separate iterations in each).
Workload: Each iteration yields one credit and includes 6-12 hours of contact

sessions and 10-20 hours of individual or group work.
Learning Outcomes: After taking this course, you are able to plan your studies in Software and Service Engineering major; analyze what you have learned from the courses and work experience so far; and create a learning portfolio. In addition, you are able to recognize your professional identity and network with other students in the Software and Service Engineering major.
Content: Reflection and planning of the studies in Software and Service Engineering major. Reflection and analysis of the professional identity and work experience.
Assessment Methods and Criteria: Study plan and learning portfolio; details vary between each iteration.
Study Material: To be announced later.
Substitutes for Courses: CSE-E5695 Portfolio in Software and Service Engineering
Prerequisites: This course is meant only for the students in Software and Service Engineering major.
Grading Scale: pass/fail
Registration for Courses: Registration via WebOodi.
Language of Instruction: English
Further Information: The course is modular: the student can participate in separate 1 cr iterations to accumulate up to 5 credits. The course takes place in three iterations: one in the beginning of period I, one in the beginning of period III; and one in the end of period V.
The course is highly recommended to be started in the first period I of the major studies. However, students in any phases of their major studies are welcome to participate the course. Please see the course home page for further information. Only for students in the Software and Service Engineering major.

CS-E4930 Software Processes and Projects (5 cr)

Responsible teacher: Maria Paasivaara; Ville Heikkilä; Casper Lassenius
Status of the Course: Optional course of the Software and Service Engineering major.
Level of the Course: Master's level
Teaching period: IV-V (Spring)
Workload: Lectures 40 h (4 h / week). Independent work 95 h: Lecture diaries, assignments.
Learning Outcomes: You can create a project plan and schedule for a small-scale software project, you can discuss about different kinds of software project types (customer specific, product development and distributed project), you can apply different methods for software project management, you can select the most appropriate process model for a software project.
Content: Software project planning and management. Project organization, project/process models, different project types (bespoke, software product and distributed projects), communication and global software development.
Assessment Methods and Criteria: Assignments and lecture diaries.
Study Material: Article collection + lecture slides

Substitutes for Courses: Replaces former courses CSE-E4600 / T-76.5612 Software Project Management.
Prerequisites: CS-C3150 / CSE-C3610/T-76.3601 (Introduction to) Software Engineering, TU-A1100 Tuotantotalous 1 (industrial engineering). In case Bachelor's Degree has been awarded in a university other than Aalto University, equivalent courses are acceptable.
Evaluation: 0-5
Registration for Courses: Registration via WebOodi.
Language of Instruction: English
Further Information:
The number of participants will be limited to 40. Registrations will be prioritized in the following order:
1) The students that have the course as a mandatory part of their major,
2) The students that have the course as a mandatory part of their minor,
3) The students that have the course as an elective part of their major,
4) The students that have the course as an elective part of their minor,
5) Other students of the Department of Computer Science, and
6) All other students.
Inside the aforementioned classes, the selection is based on the chronological registration order.

CS-E4930 Software Processes and Projects (5 sp)

Ansvarig lärare: Maria Paasivaara; Ville Heikkilä; Casper Lassenius
Kursens status: Optional course of the Software and Service Engineering major.
Kursnivå: Master's level
Undervisningsperiod: IV-V (Spring)
Arbetsmängd: Lectures 40 h (4 h / week). Independent work 95 h: Lecture diaries, assignments.
Lärandemål: You can create a project plan and schedule for a small-scale software project, you can discuss about different kinds of software project types (customer specific, product development and distributed project), you can apply different methods for software project management, you can select the most appropriate process model for a software project.
Innehåll: Software project planning and management. Project organization, project/process models, different project types (bespoke, software product and distributed projects), communication and global software development.
Metoder, arbetssätt och bedömningsgrunder: Assignments and lecture diaries.
Studiematerial: Article collection + lecture slides
Ersättande prestationer: Replaces former courses CSE-E4600 / T-76.5612 Software Project Management.
Förkunskaper: CS-C3150 / CSE-C3610/T-76.3601 (Introduction to) Software Engineering, TU-A1100 Tuotantotalous 1 (industrial engineering). In case Bachelor's Degree has been awarded in a university other than Aalto University, equivalent courses are acceptable.
Bedömningsskala: 0-5
Anmälning: Registration via WebOodi.

Undervisningsspråk: English
Tilläggsinformation:
The number of participants will be limited to 40. Registrations will be prioritized in the following order:
1) The students that have the course as a mandatory part of their major,
2) The students that have the course as a mandatory part of their minor,
3) The students that have the course as an elective part of their major,
4) The students that have the course as an elective part of their minor,
5) Other students of the Department of Computer Science, and
6) All other students.
Inside the aforementioned classes, the selection is based on the chronological registration order.

CS-E4930 Software Processes and Projects (5 cr)

Responsible teacher: Maria Paasivaara; Ville Heikkilä; Casper Lassenius
Status of the Course: Optional course of the Software and Service Engineering major.
Level of the Course: Master's level
Teaching Period: IV-V (Spring)
Workload: Lectures 40 h (4 h / week). Independent work 95 h: Lecture diaries, assignments.
Learning Outcomes: You can create a project plan and schedule for a small-scale software project, you can discuss about different kinds of software project types (customer specific, product development and distributed project), you can apply different methods for software project management, you can select the most appropriate process model for a software project.
Content: Software project planning and management. Project organization, project/process models, different project types (bespoke, software product and distributed projects), communication and global software development.
Assessment Methods and Criteria: Assignments and lecture diaries.
Study Material: Article collection + lecture slides
Substitutes for Courses: Replaces former courses CSE-E4600 / T-76.5612 Software Project Management.
Prerequisites: CS-C3150 / CSE-C3610/T-76.3601 (Introduction to) Software Engineering, TU-A1100 Tuotantotalous 1 (industrial engineering). In case Bachelor's Degree has been awarded in a university other than Aalto University, equivalent courses are acceptable.
Grading Scale: 0-5
Registration for Courses: Registration via WebOodi.
Language of Instruction: English
Further Information:
The number of participants will be limited to 40. Registrations will be prioritized in the following order:
1) The students that have the course as a mandatory part of their major,
2) The students that have the course as a mandatory part of their minor,
3) The students that have the course as an elective part of their major,

4) The students that have the course as an elective part of their minor,
5) Other students of the Department of Computer Science, and
6) All other students.
Inside the aforementioned classes, the selection is based on the chronological registration order.

CS-E4940 Requirements Engineering (5 cr)

Responsible teacher: Marjo Kauppinen
Status of the Course: Optional course of the Software and Service Engineering major.
Level of the Course: Master's level
Teaching period: III – V (Spring)
Workload: Study sessions (lectures): 30, Assignments and individual work: 50h, Group assignment and workshops: 50h.
Learning Outcomes: You know and can explain what the key areas and activities of requirements engineering (RE) are. You also learn to select good RE practices for development projects. After the course, you can relate RE to other processes. You also learn to combine and apply different RE approaches when creating software-intensive products and services.
Content: After the course, the student will have a broad understanding of requirements engineering and its role in system, product and service development. The key topics of the course are: 1) flexible usage of good RE practices, 2) customer value creation, 3) linking RE with long-term planning and development, and 4) RE from the perspectives of creativity, co-creation and services.
Assessment Methods and Criteria: Assignments and oral examination.
Study Material: A set of articles that relate to the key topics of the course.
Evaluation: 0-5
Registration for Courses: Registration via WebOodi.
Language of Instruction: English
Further Information:
The number of participants will be limited (40). Registrations will be prioritized in the following order:
1) the students of CCIS / SSE major;
2) students that have the course as a mandatory or elective part of their major or minor;
3) all other students based on registration order.

CS-E4940 Requirements Engineering (5 sp)

Ansvarig lärare: Marjo Kauppinen
Kursens status: Optional course of the Software and Service Engineering major.
Kursnivå: Master's level
Undervisningsperiod: III – V (Spring)
Arbetsmängd: Study sessions (lectures): 30, Assignments and individual work: 50h, Group assignment and workshops: 50h.
Lärandemål: You know and can explain what the key areas and activities of requirements engineering (RE) are. You also learn to select good RE practices for

development projects. After the course, you can relate RE to other processes. You also learn to combine and apply different RE approaches when creating software-intensive products and services.
Innehåll: After the course, the student will have a broad understanding of requirements engineering and its role in system, product and service development. The key topics of the course are: 1) flexible usage of good RE practices, 2) customer value creation, 3) linking RE with long-term planning and development, and 4) RE from the perspectives of creativity, co-creation and services.
Metoder, arbetssätt och bedömningsgrunder: Assignments and oral examination.
Studiematerial: A set of articles that relate to the key topics of the course.
Bedömningsskala: 0-5
Anmälning: Registration via WebOodi.
Undervisningsspråk: English
Tilläggsinformation:
The number of participants will be limited (40). Registrations will be prioritized in the following order:
1) the students of CCIS / SSE major;
2) students that have the course as a mandatory or elective part of their major or minor;
3) all other students based on registration order.

CS-E4940 Requirements Engineering (5 cr)

Responsible teacher: Marjo Kauppinen
Status of the Course: Optional course of the Software and Service Engineering major.
Level of the Course: Master's level
Teaching Period: III – V (Spring)
Workload: Study sessions (lectures): 30, Assignments and individual work: 50h, Group assignment and workshops: 50h.
Learning Outcomes: You know and can explain what the key areas and activities of requirements engineering (RE) are. You also learn to select good RE practices for development projects. After the course, you can relate RE to other processes. You also learn to combine and apply different RE approaches when creating software-intensive products and services.
Content: After the course, the student will have a broad understanding of requirements engineering and its role in system, product and service development. The key topics of the course are: 1) flexible usage of good RE practices, 2) customer value creation, 3) linking RE with long-term planning and development, and 4) RE from the perspectives of creativity, co-creation and services.
Assessment Methods and Criteria: Assignments and oral examination.
Study Material: A set of articles that relate to the key topics of the course.
Grading Scale: 0-5
Registration for Courses: Registration via WebOodi.
Language of Instruction: English
Further Information:

The number of participants will be limited (40). Registrations will be prioritized in the following order:
1) the students of CCIS / SSE major;
2) students that have the course as a mandatory or elective part of their major or minor;
3) all other students based on registration order.

CS-E4950 Software Architectures (5 cr)

Responsible teacher: Varvana Myllärniemi; Kari Smolander
Level of the Course: The course is only for students who have completed their Bachelor's Degree.
Teaching period: III-V (Spring)
Workload: Contact sessions 30 h, project work 65 h, individual work 35 h
Learning Outcomes: After taking this course, the student is able to...

- analyze the architecturally significant requirements and scenarios based on the stakeholder concerns for an open-ended, complex problem.
- design a high-level architecture that tries to address the architecturally significant requirements and scenarios; the design is created iteratively and as team work.
- model and document the design and design decisions using multiple views and viewpoints and in a consistent fashion.
- evaluate whether the high-level architecture design addresses the scenarios.
- analyze and present all aforementioned orally.

Content: The course content in a nutshell: How to design a software architecture that meets the needs of its stakeholders? The course takes a practical hands-on approach: the content is applied in the project work that lasts throughout the course.
Assessment Methods and Criteria: Project work, oral exam.
Study Material: Lectures, reading material.
Substitutes for Courses: Replaces the former course T-76.5150 Software Architectures
Prerequisites: CS-C3180 / CSE-C3600 Software Design and Modelling OR similar knowledge. Also, it is highly advisable to have experience in programming and software development.
Evaluation: 0-5
Registration for Courses: Registration via WebOodi.
Language of Instruction: English
Further Information: The course is targeted for software and service engineering major / minor students. The course is also suitable for those students who have previous work experience as software developers and aspire to become software architects in the future.

CS-E4950 Software Architectures (5 sp)

Ansvarig lärare: Varvana Myllärniemi; Kari Smolander
Kursnivå: The course is only for students who have completed their Bachelor's

Degree.
Undervisningsperiod: III-V (Spring)
Arbetsmängd: Contact sessions 30 h, project work 65 h, individual work 35 h
Lärandemål: After taking this course, the student is able to...

- analyze the architecturally significant requirements and scenarios based on the stakeholder concerns for an open-ended, complex problem.
- design a high-level architecture that tries to address the architecturally significant requirements and scenarios; the design is created iteratively and as team work.
- model and document the design and design decisions using multiple views and viewpoints and in a consistent fashion.
- evaluate whether the high-level architecture design addresses the scenarios.
- analyze and present all aforementioned orally.

Innehåll: The course content in a nutshell: How to design a software architecture that meets the needs of its stakeholders? The course takes a practical hands-on approach: the content is applied in the project work that lasts throughout the course.
Metoder, arbetssätt och bedömningsgrunder: Project work, oral exam.
Studiematerial: Lectures, reading material.
Ersättande prestationer: Replaces the former course T-76.5150 Software Architectures
Förkunskaper: CS-C3180 / CSE-C3600 Software Design and Modelling OR similar knowledge. Also, it is highly advisable to have experience in programming and software development.
Bedömningsskala: 0-5
Anmälning: Registration via WebOodi.
Undervisningsspråk: English
Tilläggsinformation: The course is targeted for software and service engineering major / minor students. The course is also suitable for those students who have previous work experience as software developers and aspire to become software architects in the future.

CS-E4950 Software Architectures (5 cr)

Responsible teacher: Varvana Myllärniemi; Kari Smolander
Level of the Course: The course is only for students who have completed their Bachelor's Degree.
Teaching Period: III-V (Spring)
Workload: Contact sessions 30 h, project work 65 h, individual work 35 h
Learning Outcomes: After taking this course, the student is able to...

- analyze the architecturally significant requirements and scenarios based on the stakeholder concerns for an open-ended, complex problem.
- design a high-level architecture that tries to address the architecturally significant requirements and scenarios; the design is created iteratively and as team work.

- model and document the design and design decisions using multiple views and viewpoints and in a consistent fashion.
- evaluate whether the high-level architecture design addresses the scenarios.
- analyze and present all aforementioned orally.

Content: The course content in a nutshell: How to design a software architecture that meets the needs of its stakeholders? The course takes a practical hands-on approach: the content is applied in the project work that lasts throughout the course.
Assessment Methods and Criteria: Project work, oral exam.
Study Material: Lectures, reading material.
Substitutes for Courses: Replaces the former course T-76.5150 Software Architectures
Prerequisites: CS-C3180 / CSE-C3600 Software Design and Modelling OR similar knowledge. Also, it is highly advisable to have experience in programming and software development.
Grading Scale: 0-5
Registration for Courses: Registration via WebOodi.
Language of Instruction: English
Further Information: The course is targeted for software and service engineering major / minor students. The course is also suitable for those students who have previous work experience as software developers and aspire to become software architects in the future.

CS-E4960 Software Testing and Quality Assurance (5 cr)

Responsible teacher: Casper Lassenius
Level of the Course: The course is only for students who have completed their Bachelor's Degree.
Teaching period: II-III
Workload: Lectures 26 h, group work 52 h, individual work 39 h
Learning Outcomes: You know and can define the essential concepts of testing and software quality. You understand the objectives of software testing and the significance of testing and quality assurance as part of software engineering. You know different ways of organizing testing, common testing techniques as well as other quality practices. You can select and apply appropriate quality practices in different situations and understand the strengths and weaknesses of the practices. You understand the purposes that testing tools and test automation can be used and the typical challenges of test automation.
Content: Basics of software testing, concepts, testing techniques and reviews. Test planning, management and tools. The role of testing in quality assurance and quality assurance as part of software process.
Assessment Methods and Criteria: Lectures, assignments, exercise work and possibly exam.
Study Material: Delivered to the students when the course begins.
Substitutes for Courses: Replaces the former course T-76.5613 Software Testing and Quality Assurance
Prerequisites: CS-C3150 / CSE-C3610 Software Engineering (mandatory),

CS-C3600 / CSE-C3600 Software Design and Modelling (recommended).
Evaluation: 0-5
Language of Instruction: English

CS-E4960 Software Testing and Quality Assurance (5 sp)

Ansvarig lärare: Casper Lassenius
Kursnivå: The course is only for students who have completed their Bachelor's Degree.
Undervisningsperiod: II-III
Arbetsmängd: Lectures 26 h, group work 52 h, individual work 39 h
Lärandemål: You know and can define the essential concepts of testing and software quality. You understand the objectives of software testing and the significance of testing and quality assurance as part of software engineering. You know different ways of organizing testing, common testing techniques as well as other quality practices. You can select and apply appropriate quality practices in different situations and understand the strengths and weaknesses of the practices. You understand the purposes that testing tools and test automation can be used and the typical challenges of test automation.
Innehåll: Basics of software testing, concepts, testing techniques and reviews. Test planning, management and tools. The role of testing in quality assurance and quality assurance as part of software process.
Metoder, arbetssätt och bedömningsgrunder: Lectures, assignments, exercise work and possibly exam.
Studiematerial: Delivered to the students when the course begins.
Ersättande prestationer: Replaces the former course T-76.5613 Software Testing and Quality Assurance
Förkunskaper: CS-C3150 / CSE-C3610 Software Engineering (mandatory), CS-C3600 / CSE-C3600 Software Design and Modelling (recommended).
Bedömningsskala: 0-5
Undervisningsspråk: English

CS-E4960 Software Testing and Quality Assurance (5 cr)

Responsible teacher: Casper Lassenius
Level of the Course: The course is only for students who have completed their Bachelor's Degree.
Teaching Period: II-III
Workload: Lectures 26 h, group work 52 h, individual work 39 h
Learning Outcomes: You know and can define the essential concepts of testing and software quality. You understand the objectives of software testing and the significance of testing and quality assurance as part of software engineering. You know different ways of organizing testing, common testing techniques as well as other quality practices. You can select and apply appropriate quality practices in different situations and understand the strengths and weaknesses of the practices. You understand the purposes that testing tools and test automation can be used and the typical challenges of test automation.
Content: Basics of software testing, concepts, testing techniques and reviews.

Test planning, management and tools. The role of testing in quality assurance and quality assurance as part of software process.
Assessment Methods and Criteria: Lectures, assignments, exercise work and possibly exam.
Study Material: Delivered to the students when the course begins.
Substitutes for Courses: Replaces the former course T-76.5613 Software Testing and Quality Assurance
Prerequisites: CS-C3150 / CSE-C3610 Software Engineering (mandatory), CS-C3600 / CSE-C3600 Software Design and Modelling (recommended).
Grading Scale: 0-5
Language of Instruction: English

CS-E4970 Individual Study in Software Business(V) (2-16 cr)

Responsible teacher: Marjo Kauppinen
Teaching period: According to agreement.
Learning Outcomes: Based on this course, the student can either analyze, plan, and make recommendations on a practical technology business situation or prepare a scientific study in the field.
Content: Varies according to situation and agreement.
Assessment Methods and Criteria: Varies according to situation and agreement.
Study Material: Agreed with the responsible teacher.
Substitutes for Courses: Replaces the former course T-128.5780 Individual Study in Software Business
Evaluation: 0-5
Language of Instruction: English
Further Information: The contents of the course vary.

CS-E4970 Individual Study in Software Business(V) (2-16 sp)

Ansvarig lärare: Marjo Kauppinen
Undervisningsperiod: According to agreement.
Lärandemål: Based on this course, the student can either analyze, plan, and make recommendations on a practical technology business situation or prepare a scientific study in the field.
Innehåll: Varies according to situation and agreement.
Metoder, arbetssätt och bedömningsgrunder: Varies according to situation and agreement.
Studiematerial: Agreed with the responsible teacher.
Ersättande prestationer: Replaces the former course T-128.5780 Individual Study in Software Business
Bedömningsskala: 0-5
Undervisningsspråk: English
Tilläggsinformation: The contents of the course vary.

CS-E4970 Individual Study in Software Business(V) (2-16 cr)

Responsible teacher: Marjo Kauppinen

Teaching Period: According to agreement.
Learning Outcomes: Based on this course, the student can either analyze, plan, and make recommendations on a practical technology business situation or prepare a scientific study in the field.
Content: Varies according to situation and agreement.
Assessment Methods and Criteria: Varies according to situation and agreement.
Study Material: Agreed with the responsible teacher.
Substitutes for Courses: Replaces the former course T-128.5780 Individual Study in Software Business
Grading Scale: 0-5
Language of Instruction: English
Further Information: The contents of the course vary.

CS-E5000 Seminar in Software and Service Engineering(V) (5 cr)

Responsible teacher: Martti Mäntylä; Marko Nieminen; Marjo Kauppinen; Casper Lassenius
Status of the Course: Compulsory or optional course depending on the track of the Software and Service Engineering major.
Level of the Course: Master's level
Teaching period: I - II (Autumn), III - V (Spring)
Learning Outcomes: Students are able to search information related to a research topic, analyze information from different sources and write a scientific report in English. Students also improve their skills to carry out Master's Thesis.
Content: The contents of this course vary.
Substitutes for Courses: Replaces former courses CSE-E5690 Seminar in Software and Service Engineering, T-76.5650 Seminar in Software Engineering, T-86.5200 Service Research Seminar, and T-121.5900 Seminar on User Interfaces and Usability.
Evaluation: 0-5
Registration for Courses: Registration via WebOodi.
Language of Instruction: English or Finnish.
Further Information: Language of the instruction is Finnish or English. Language will be announced in MyCourses at the beginning of the course. This seminar is especially targeted to students planning or carrying out their Master's Thesis.

CS-E5000 Seminar in Software and Service Engineering(V) (5 sp)

Ansvarig lärare: Martti Mäntylä; Marko Nieminen; Marjo Kauppinen; Casper Lassenius
Kursens status: Compulsory or optional course depending on the track of the Software and Service Engineering major.
Kursnivå: Master's level
Undervisningsperiod: I - II (Autumn), III - V (Spring)
Lärandemål: Students are able to search information related to a research topic, analyze information from different sources and write a scientific report in English. Students also improve their skills to carry out Master's Thesis.

Innehåll: The contents of this course vary.
Ersättande prestationer: Replaces former courses CSE-E5690 Seminar in Software and Service Engineering, T-76.5650 Seminar in Software Engineering, T-86.5200 Service Research Seminar, and T-121.5900 Seminar on User Interfaces and Usability.
Bedömningsskala: 0-5
Anmälning: Registration via WebOodi.
Undervisningsspråk: English or Finnish.
Tilläggsinformation: Language of the instruction is Finnish or English. Language will be announced in MyCourses at the beginning of the course. This seminar is especially targeted to students planning or carrying out their Master's Thesis.

CS-E5000 Seminar in Software and Service Engineering(V) (5 cr)

Responsible teacher: Martti Mäntylä; Marko Nieminen; Marjo Kauppinen; Casper Lassenius
Status of the Course: Compulsory or optional course depending on the track of the Software and Service Engineering major.
Level of the Course: Master's level
Teaching Period: I - II (Autumn), III - V (Spring)
Learning Outcomes: Students are able to search information related to a research topic, analyze information from different sources and write a scientific report in English. Students also improve their skills to carry out Master's Thesis.
Content: The contents of this course vary.
Substitutes for Courses: Replaces former courses CSE-E5690 Seminar in Software and Service Engineering, T-76.5650 Seminar in Software Engineering, T-86.5200 Service Research Seminar, and T-121.5900 Seminar on User Interfaces and Usability.
Grading Scale: 0-5
Registration for Courses: Registration via WebOodi.
Language of Instruction: English or Finnish.
Further Information: Language of the instruction is Finnish or English. Language will be announced in MyCourses at the beginning of the course. This seminar is especially targeted to students planning or carrying out their Master's Thesis.

CS-E5001 Research Seminar in Software and Service Engineering(V) (5 cr)

Responsible teacher: Martti Mäntylä; Marko Nieminen; Marjo Kauppinen; Casper Lassenius; Kari Smolander
Status of the Course: Compulsory or optional course depending on the track of the Software and Service Engineering major.
Level of the Course: Master's level
Teaching period: I - II (Autumn), III - V (Spring)
Learning Outcomes: Students learn to conduct research on a contemporary topic in software and service engineering. This includes searching for information related to the research topic, optionally collecting empirical data, as well as

analyzing and synthesizing the information, and the reporting of the findings in a scientific report. The seminar prepares the students for writing scientific publications, as well as their Master's thesis.
Content: The contents of this course vary.
Substitutes for Courses: Replaces former courses T-76.5655 Research seminar in Software Engineering and CSE-E5670 Seminar on Industrial Internet.
Evaluation: 0-5
Language of Instruction: English or Finnish

CS-E5001 Research Seminar in Software and Service Engineering(V) (5 sp)

Ansvarig lärare: Martti Mäntylä; Marko Nieminen; Marjo Kauppinen; Casper Lassenius; Kari Smolander
Kursens status: Compulsory or optional course depending on the track of the Software and Service Engineering major.
Kursnivå: Master's level
Undervisningsperiod: I - II (Autumn), III - V (Spring)
Lärandemål: Students learn to conduct research on a contemporary topic in software and service engineering. This includes searching for information related to the research topic, optionally collecting empirical data, as well as analyzing and synthesizing the information, and the reporting of the findings in a scientific report. The seminar prepares the students for writing scientific publications, as well as their Master's thesis.
Innehåll: The contents of this course vary.
Ersättande prestationer: Replaces former courses T-76.5655 Research seminar in Software Engineering and CSE-E5670 Seminar on Industrial Internet.
Bedömningsskala: 0-5
Undervisningsspråk: English or Finnish

CS-E5001 Research Seminar in Software and Service Engineering(V) (5 cr)

Responsible teacher: Martti Mäntylä; Marko Nieminen; Marjo Kauppinen; Casper Lassenius; Kari Smolander
Status of the Course: Compulsory or optional course depending on the track of the Software and Service Engineering major.
Level of the Course: Master's level
Teaching Period: I - II (Autumn), III - V (Spring)
Learning Outcomes: Students learn to conduct research on a contemporary topic in software and service engineering. This includes searching for information related to the research topic, optionally collecting empirical data, as well as analyzing and synthesizing the information, and the reporting of the findings in a scientific report. The seminar prepares the students for writing scientific publications, as well as their Master's thesis.
Content: The contents of this course vary.
Substitutes for Courses: Replaces former courses T-76.5655 Research seminar in Software Engineering and CSE-E5670 Seminar on Industrial Internet.
Grading Scale: 0-5
Language of Instruction: English or Finnish

CS-E5002 Special Course in Software and Service Engineering(V) (1-10 cr)

Responsible teacher: Martti Mäntylä; Marko Nieminen; Marjo Kauppinen; Casper Lassenius
Level of the Course: Master's level
Teaching period: (Arranged when needed)
Content: The contents of this course vary.
Substitutes for Courses: Replaces former courses CSE-E5697 Special Course in Software and Service Engineering and CSE-E6250 Digital Service Design, Course with Varying Content.
Evaluation: 0-5
Language of Instruction: English

CS-E5002 Special Course in Software and Service Engineering(V) (1-10 sp)

Ansvarig lärare: Martti Mäntylä; Marko Nieminen; Marjo Kauppinen; Casper Lassenius
Kursnivå: Master's level
Undervisningsperiod: (Arranged when needed)
Innehåll: The contents of this course vary.
Ersättande prestationer: Replaces former courses CSE-E5697 Special Course in Software and Service Engineering and CSE-E6250 Digital Service Design, Course with Varying Content.
Bedömningsskala: 0-5
Undervisningsspråk: English

CS-E5002 Special Course in Software and Service Engineering(V) (1-10 cr)

Responsible teacher: Martti Mäntylä; Marko Nieminen; Marjo Kauppinen; Casper Lassenius
Level of the Course: Master's level
Teaching Period: (Arranged when needed)
Content: The contents of this course vary.
Substitutes for Courses: Replaces former courses CSE-E5697 Special Course in Software and Service Engineering and CSE-E6250 Digital Service Design, Course with Varying Content.
Grading Scale: 0-5
Language of Instruction: English

CS-E5004 Individual Studies in Software and Service Engineering(V) (1-10 cr)

Responsible teacher: Martti Mäntylä; Marko Nieminen; Marjo Kauppinen; Casper Lassenius
Level of the Course: Master's level
Teaching period: (Arranged when needed)
Content: The scope and content of the course must be agreed with the teacher before starting the course.

Substitutes for Courses: Replaces former courses CES-E5699 Individual Studies in Software and Service Engineering (V), T-76.5699 Ohjelmistotuotannon yksilölliset opinnot and T-121.5850 Individual Course on Usability.
Evaluation: 0-5
Language of Instruction: English or Finnish.

CS-E5004 Individual Studies in Software and Service Engineering(V) (1-10 sp)

Ansvarig lärare: Martti Mäntylä; Marko Nieminen; Marjo Kauppinen; Casper Lassenius
Kursnivå: Master's level
Undervisningsperiod: (Arranged when needed)
Innehåll: The scope and content of the course must be agreed with the teacher before starting the course.
Ersättande prestationer: Replaces former courses CES-E5699 Individual Studies in Software and Service Engineering (V), T-76.5699 Ohjelmistotuotannon yksilölliset opinnot and T-121.5850 Individual Course on Usability.
Bedömningsskala: 0-5
Undervisningsspråk: English or Finnish.

CS-E5004 Individual Studies in Software and Service Engineering(V) (1-10 cr)

Responsible teacher: Martti Mäntylä; Marko Nieminen; Marjo Kauppinen; Casper Lassenius
Level of the Course: Master's level
Teaching Period: (Arranged when needed)
Content: The scope and content of the course must be agreed with the teacher before starting the course.
Substitutes for Courses: Replaces former courses CES-E5699 Individual Studies in Software and Service Engineering (V), T-76.5699 Ohjelmistotuotannon yksilölliset opinnot and T-121.5850 Individual Course on Usability.
Grading Scale: 0-5
Language of Instruction: English or Finnish.

CS-E5005 Research Methods in Software and Service Engineering (5 cr)

Responsible teacher: Sari Kujala; Kari Smolander; Marjo Kauppinen
Level of the Course: The course is only for students who have completed their Bachelor's Degree.
Teaching period: I-II (Autumn)
Workload: Lectures 14 h, individual studies 16 h, assignment 100 h.
Learning Outcomes: Students are able to understand scientific research and evaluate the validity and reliability of research results. They are able to plan an empirical study, collect and analyze data, and report the results. Students improve their skills to carry out Master's Thesis.

Content: The goal is to introduce the participants to scientific research methods, approaches and processes used in the field of software engineering. In addition, the course provides students practice on formulating research questions and planning empirical studies.
Assessment Methods and Criteria: Assignments and classroom activity.
Study Material: To be announced later.
Substitutes for Courses: Replaces the former course T-76.5050 Methods for Software Engineering and Business Research.
Course Homepage: https://mycourses.aalto.fi/course/view.php?id=8880
Evaluation: 0-5
Registration for Courses: Registration via WebOodi.
Language of Instruction: English
Further Information:
This seminar is especially targeted to students planning or carrying out their Master's Thesis.
The number of participants will be limited (30). Registrations will be prioritized in the following order:
1) the students of CCIS / SSE major;
2) students that have the course as a mandatory or elective part of their major or minor;
3) all other students based on registration order.

CS-E5005 Research Methods in Software and Service Engineering (5 sp)

Ansvarig lärare: Sari Kujala; Kari Smolander; Marjo Kauppinen
Kursnivå: The course is only for students who have completed their Bachelor's Degree.
Undervisningsperiod: I-II (Autumn)
Arbetsmängd: Lectures 14 h, individual studies 16 h, assignment 100 h.
Lärandemål: Students are able to understand scientific research and evaluate the validity and reliability of research results. They are able to plan an empirical study, collect and analyze data, and report the results. Students improve their skills to carry out Master's Thesis.
Innehåll: The goal is to introduce the participants to scientific research methods, approaches and processes used in the field of software engineering. In addition, the course provides students practice on formulating research questions and planning empirical studies.
Metoder, arbetssätt och bedömningsgrunder: Assignments and classroom activity.
Studiematerial: To be announced later.
Ersättande prestationer: Replaces the former course T-76.5050 Methods for Software Engineering and Business Research.
Kursens webbplats: https://mycourses.aalto.fi/course/view.php?id=8880
Bedömningsskala: 0-5
Anmälning: Registration via WebOodi.
Undervisningsspråk: English
Tilläggsinformation:

This seminar is especially targeted to students planning or carrying out their Master's Thesis.
The number of participants will be limited (30). Registrations will be prioritized in the following order:
1) the students of CCIS / SSE major;
2) students that have the course as a mandatory or elective part of their major or minor;
3) all other students based on registration order.

CS-E5005 Research Methods in Software and Service Engineering (5 cr)

Responsible teacher: Sari Kujala; Kari Smolander; Marjo Kauppinen
Level of the Course: The course is only for students who have completed their Bachelor's Degree.
Teaching Period: I-II (Autumn)
Workload: Lectures 14 h, individual studies 16 h, assignment 100 h.
Learning Outcomes: Students are able to understand scientific research and evaluate the validity and reliability of research results. They are able to plan an empirical study, collect and analyze data, and report the results. Students improve their skills to carry out Master's Thesis.
Content: The goal is to introduce the participants to scientific research methods, approaches and processes used in the field of software engineering. In addition, the course provides students practice on formulating research questions and planning empirical studies.
Assessment Methods and Criteria: Assignments and classroom activity.
Study Material: To be announced later.
Substitutes for Courses: Replaces the former course T-76.5050 Methods for Software Engineering and Business Research.
Course Homepage: https://mycourses.aalto.fi/course/view.php?id=8880
Grading Scale: 0-5
Registration for Courses: Registration via WebOodi.
Language of Instruction: English
Further Information:
This seminar is especially targeted to students planning or carrying out their Master's Thesis.
The number of participants will be limited (30). Registrations will be prioritized in the following order:
1) the students of CCIS / SSE major;
2) students that have the course as a mandatory or elective part of their major or minor;
3) all other students based on registration order.

CS-E5006 Doctoral Seminar(V) (2-8 cr)

Responsible teacher: Sari Kujala; Marjo Kauppinen
Teaching period: I-IV, (Autumn & Spring)
Learning Outcomes: The goal of the doctoral seminar is to support Ph.D. students in their research and writing work. The essential feature of the seminar is

that participants are presenting their research plans and results, discussing with each other and sharing experiences. The goal is that Ph.D. students get feedback on their research work and texts. They also learn to analyze and review scientific articles.
Content: In addition to students' own presentations, there are theme lectures and expert presentations. The goal of theme lectures is give information about Ph.D. process and research methods, and how they can be applied in practice. The basic information of the research methods is given in the course T-76.5050 Methods for Software Engineering and Business Research.
Assessment Methods and Criteria: Participation in seminar sessions and seminar presentations.
Substitutes for Courses: Replaces the former course T-76.7656 Doctoral Seminar.
Course Homepage: https://mycourses.aalto.fi/course/view.php?id=10111
Evaluation: pass/fail
Language of Instruction: English
Further Information: The content of the course varies.

CS-E5006 Doctoral Seminar(V) (2-8 sp)

Ansvarig lärare: Sari Kujala; Marjo Kauppinen
Undervisningsperiod: I-IV, (Autumn & Spring)
Lärandemål: The goal of the doctoral seminar is to support Ph.D. students in their research and writing work. The essential feature of the seminar is that participants are presenting their research plans and results, discussing with each other and sharing experiences. The goal is that Ph.D. students get feedback on their research work and texts. They also learn to analyze and review scientific articles.
Innehåll: In addition to students' own presentations, there are theme lectures and expert presentations. The goal of theme lectures is give information about Ph.D. process and research methods, and how they can be applied in practice. The basic information of the research methods is given in the course T-76.5050 Methods for Software Engineering and Business Research.
Metoder, arbetssätt och bedömningsgrunder: Participation in seminar sessions and seminar presentations.
Ersättande prestationer: Replaces the former course T-76.7656 Doctoral Seminar.
Kursens webbplats: https://mycourses.aalto.fi/course/view.php?id=10111
Bedömningsskala: pass/fail
Undervisningsspråk: English
Tilläggsinformation: The content of the course varies.

CS-E5006 Doctoral Seminar(V) (2-8 cr)

Responsible teacher: Sari Kujala; Marjo Kauppinen
Teaching Period: I-IV, (Autumn & Spring)
Learning Outcomes: The goal of the doctoral seminar is to support Ph.D. students in their research and writing work. The essential feature of the seminar is

that participants are presenting their research plans and results, discussing with each other and sharing experiences. The goal is that Ph.D. students get feedback on their research work and texts. They also learn to analyze and review scientific articles.
Content: In addition to students' own presentations, there are theme lectures and expert presentations. The goal of theme lectures is give information about Ph.D. process and research methods, and how they can be applied in practice. The basic information of the research methods is given in the course T-76.5050 Methods for Software Engineering and Business Research.
Assessment Methods and Criteria: Participation in seminar sessions and seminar presentations.
Substitutes for Courses: Replaces the former course T-76.7656 Doctoral Seminar.
Course Homepage: https://mycourses.aalto.fi/course/view.php?id=10111
Grading Scale: pass/fail
Language of Instruction: English
Further Information: The content of the course varies.

CS-E5100 Introduction to IT Business and Venturing (2 cr)

Responsible teacher: Olli Mutanen
Status of the Course: Optional course of the Software and Service Engineering major. Part of the Aalto Ventures Program and EIT Master's Programme in ICT Innovation studies belonging to the 30 ECTS minor on Innovation and Entrepreneurship in ICT.
Level of the Course: Master's level
Teaching period: I-II (Autumn)
Workload: This is a 2 ECTS course. The expected student work hours are as follows: Lectures: 10 h, group assignments and related individual work: 43 h. Assignments consist of working in teams of 5 students, with the organization of the teams' work managed by each team (course personnel provides support for organization as well as group work guidance). Individual work consists of preparing for lectures and parts of assignments.
Learning Outcomes: Students learn basic characteristics of information technology business and venturing, importance of new and growing businesses to national economies, process of designing a business model for a new technology-based venture, systematically exploring customers and markets, recognizing and classifying technology and service based business models and analyzing factors in them having effect on the success of a venture.
Content: The lectures and course materials present basic information on the local, European and global IT industry and the significance of growth ventures to national economies. Theory base for technology-based entrepreneurship, markets, customer segments and firm level value creation logic is presented, and different business models based on technology or the related services are discussed. Assignments consist of business model analysis, development and design for real-life high technology startup businesses.
Assessment Methods and Criteria: The course is assessed based on business

modeling assignments about real business cases. Participation in lectures firmly supports completing the course.
Study Material: To be announced at the beginning of the course.
Substitutes for Courses: Replaces the former courses CSE-E4751 Introduction to IT Business and Venturing, T-128.4101 Introduction to Software Business and T-128.1000 Introduction to Software Business and Venturing.
Prerequisites: It is recommended that students have obtained basic information about business and software engineering.
Evaluation: 0-5
Registration for Courses: Registration via WebOodi.
Language of Instruction: English
Further Information: The number of participants will be limited. Registrations will be prioritized in the following order: The students that have the course as a mandatory part of their study program will be prioritized first. The students that are participating in the Aalto Ventures Program minor will be prioritized second. After this, all students are prioritized based on registration order.

CS-E5100 Introduction to IT Business and Venturing (2 sp)

Ansvarig lärare: Olli Mutanen
Kursens status: Optional course of the Software and Service Engineering major. Part of the Aalto Ventures Program and EIT Master's Programme in ICT Innovation studies belonging to the 30 ECTS minor on Innovation and Entrepreneurship in ICT.
Kursnivå: Master's level
Undervisningsperiod: I-II (Autumn)
Arbetsmängd: This is a 2 ECTS course. The expected student work hours are as follows: Lectures: 10 h, group assignments and related individual work: 43 h. Assignments consist of working in teams of 5 students, with the organization of the teams' work managed by each team (course personnel provides support for organization as well as group work guidance). Individual work consists of preparing for lectures and parts of assignments.
Lärandemål: Students learn basic characteristics of information technology business and venturing, importance of new and growing businesses to national economies, process of designing a business model for a new technology-based venture, systematically exploring customers and markets, recognizing and classifying technology and service based business models and analyzing factors in them having effect on the success of a venture.
Innehåll: The lectures and course materials present basic information on the local, European and global IT industry and the significance of growth ventures to national economies. Theory base for technology-based entrepreneurship, markets, customer segments and firm level value creation logic is presented, and different business models based on technology or the related services are discussed. Assignments consist of business model analysis, development and design for real-life high technology startup businesses.
Metoder, arbetssätt och bedömningsgrunder: The course is assessed based on business modeling assignments about real business cases. Participation in lectures

firmly supports completing the course.
Studiematerial: To be announced at the beginning of the course.
Ersättande prestationer: Replaces the former courses CSE-E4751 Introduction to IT Business and Venturing, T-128.4101 Introduction to Software Business and T-128.1000 Introduction to Software Business and Venturing.
Förkunskaper: It is recommended that students have obtained basic information about business and software engineering.
Bedömningsskala: 0-5
Anmälning: Registration via WebOodi.
Undervisningsspråk: English
Tilläggsinformation: The number of participants will be limited. Registrations will be prioritized in the following order: The students that have the course as a mandatory part of their study program will be prioritized first. The students that are participating in the Aalto Ventures Program minor will be prioritized second. After this, all students are prioritized based on registration order.

CS-E5100 Introduction to IT Business and Venturing (2 cr)

Responsible teacher: Olli Mutanen
Status of the Course: Optional course of the Software and Service Engineering major. Part of the Aalto Ventures Program and EIT Master's Programme in ICT Innovation studies belonging to the 30 ECTS minor on Innovation and Entrepreneurship in ICT.
Level of the Course: Master's level
Teaching Period: I-II (Autumn)
Workload: This is a 2 ECTS course. The expected student work hours are as follows: Lectures: 10 h, group assignments and related individual work: 43 h. Assignments consist of working in teams of 5 students, with the organization of the teams' work managed by each team (course personnel provides support for organization as well as group work guidance). Individual work consists of preparing for lectures and parts of assignments.
Learning Outcomes: Students learn basic characteristics of information technology business and venturing, importance of new and growing businesses to national economies, process of designing a business model for a new technology-based venture, systematically exploring customers and markets, recognizing and classifying technology and service based business models and analyzing factors in them having effect on the success of a venture.
Content: The lectures and course materials present basic information on the local, European and global IT industry and the significance of growth ventures to national economies. Theory base for technology-based entrepreneurship, markets, customer segments and firm level value creation logic is presented, and different business models based on technology or the related services are discussed. Assignments consist of business model analysis, development and design for real-life high technology startup businesses.
Assessment Methods and Criteria: The course is assessed based on business modeling assignments about real business cases. Participation in lectures firmly supports completing the course.

Study Material: To be announced at the beginning of the course.
Substitutes for Courses: Replaces the former courses CSE-E4751 Introduction to IT Business and Venturing, T-128.4101 Introduction to Software Business and T-128.1000 Introduction to Software Business and Venturing.
Prerequisites: It is recommended that students have obtained basic information about business and software engineering.
Grading Scale: 0-5
Registration for Courses: Registration via WebOodi.
Language of Instruction: English
Further Information: The number of participants will be limited. Registrations will be prioritized in the following order: The students that have the course as a mandatory part of their study program will be prioritized first. The students that are participating in the Aalto Ventures Program minor will be prioritized second. After this, all students are prioritized based on registration order.

CS-E5110 Management of a Technology Venture (5 cr)

Responsible teacher: Olli Mutanen; Timo Nyberg
Status of the Course: Course is part of the Aalto Ventures Program and Master's Programme in ICT Innovation studies belonging to the 30 ECTS minor on Innovation and Entrepreneurship (I&E) in ICT.
Level of the Course: Master's level
Teaching period: I-II (Autumn). Lectures start in the middle of period I (after the course CS-E5100 Introduction to IT Business and Venturing lectures).
Workload: This is a 5 ECTS course (1cr ≅ 27 work hours). The expected student work hours are: Lectures 13 x (2+2) h = 52h (includes pre-lecture material), 2 group assignments 25h + 25h = 50h, and one individual work 33h. The work hours for lectures provide students time to prepare for lectures and to discuss them afterwards. Assignments consist of working in groups.

- **Learning Outcomes:** Interested in managing ICT ventures? Want to free your mind from management preconceptions? The course provides a holistic picture of what entrepreneurs and managers of ICT ventures need to consider when establishing, developing and running their businesses. The course covers: the general processes and roles involved in developing ideas and starting up a new technology-based company or business business organization and projects
- product and process development in ICT business
- financing new businesses
- managing and developing human resources and venture capabilities
- value creation and capture, intellectual property
- and other important elements in managing a technology venture.

Lectures include insights from case studies of real firms, and first-hand experiences from industry guest lecturers.
Content: The course covers the entrepreneurial steps from the partner search and idea generation to the financing rounds and fast growth. The focus is on technology-based entrepreneurship and venture management. The course includes lectures and case studies on real high technology firms, ICT trends, business

ecosystems and markets, organization and project management, new product and process development, entrepreneurial finance and human resource development. Tools for e.g. work personality test and competency assessment are available (optional to be used in individual work). The guest lecturers, content, and the case studies vary.
Assessment Methods and Criteria: This course is assessed based on two group assignments maximum 20 points (10 each), and one individual work max 10 points. Maximum point score for the course is 30. Minimum total points required to pass the course is 15. Minimum for passing each group assignment and the individual work is 5 points. There is an optional exam.
Study Material: Lecture material, selected journal and practitioner articles, complementary materials. Materials vary from year to year, and are announced during the lectures.
Substitutes for Courses: Replaces former course CSE-E4755 Management of a Technology Venture (6 op).
Prerequisites: CS-E5100 / CSE-E4751 Introduction to IT Business and Venturing, or similar knowledge.
Evaluation: 0-5
Language of Instruction: English
Further Information: The number of participants may be limited to 60 students. Registrations will be prioritized in the following order: The students that have the course as a mandatory part of their study program will be prioritized first. The students that are participating in the Aalto Ventures Program minor will be prioritized second. After this, all students are prioritized based on registration order.

CS-E5110 Management of a Technology Venture (5 sp)

Ansvarig lärare: Olli Mutanen; Timo Nyberg
Kursens status: Course is part of the Aalto Ventures Program and Master's Programme in ICT Innovation studies belonging to the 30 ECTS minor on Innovation and Entrepreneurship (I&E) in ICT.
Kursnivå: Master's level
Undervisningsperiod: I-II (Autumn). Lectures start in the middle of period I (after the course CS-E5100 Introduction to IT Business and Venturing lectures).
Arbetsmängd: This is a 5 ECTS course (1cr ≅ 27 work hours). The expected student work hours are: Lectures 13 x (2+2) h = 52h (includes pre-lecture material), 2 group assignments 25h + 25h = 50h, and one individual work 33h. The work hours for lectures provide students time to prepare for lectures and to discuss them afterwards. Assignments consist of working in groups.

- **Lärandemål:** Interested in managing ICT ventures? Want to free your mind from management preconceptions? The course provides a holistic picture of what entrepreneurs and managers of ICT ventures need to consider when establishing, developing and running their businesses. The course covers: the general processes and roles involved in developing ideas and starting up a new technology-based company or business business organization and projects

- product and process development in ICT business
- financing new businesses
- managing and developing human resources and venture capabilities
- value creation and capture, intellectual property
- and other important elements in managing a technology venture.

Lectures include insights from case studies of real firms, and first-hand experiences from industry guest lecturers.

Innehåll: The course covers the entrepreneurial steps from the partner search and idea generation to the financing rounds and fast growth. The focus is on technology-based entrepreneurship and venture management. The course includes lectures and case studies on real high technology firms, ICT trends, business ecosystems and markets, organization and project management, new product and process development, entrepreneurial finance and human resource development. Tools for e.g. work personality test and competency assessment are available (optional to be used in individual work). The guest lecturers, content, and the case studies vary.

Metoder, arbetssätt och bedömningsgrunder: This course is assessed based on two group assignments maximum 20 points (10 each), and one individual work max 10 points. Maximum point score for the course is 30. Minimum total points required to pass the course is 15. Minimum for passing each group assignment and the individual work is 5 points. There is an optional exam.

Studiematerial: Lecture material, selected journal and practitioner articles, complementary materials. Materials vary from year to year, and are announced during the lectures.

Ersättande prestationer: Replaces former course CSE-E4755 Management of a Technology Venture (6 op).

Förkunskaper: CS-E5100 / CSE-E4751 Introduction to IT Business and Venturing, or similar knowledge.

Bedömningsskala: 0-5

Undervisningsspråk: English

Tilläggsinformation: The number of participants may be limited to 60 students. Registrations will be prioritized in the following order: The students that have the course as a mandatory part of their study program will be prioritized first. The students that are participating in the Aalto Ventures Program minor will be prioritized second. After this, all students are prioritized based on registration order.

CS-E5110 Management of a Technology Venture (5 cr)

Responsible teacher: Olli Mutanen; Timo Nyberg

Status of the Course: Course is part of the Aalto Ventures Program and Master's Programme in ICT Innovation studies belonging to the 30 ECTS minor on Innovation and Entrepreneurship (I&E) in ICT.

Level of the Course: Master's level

Teaching Period: I-II (Autumn). Lectures start in the middle of period I (after the course CS-E5100 Introduction to IT Business and Venturing lectures).

Workload: This is a 5 ECTS course (1cr ≅ 27 work hours). The expected student

work hours are: Lectures 13 x (2+2) h = 52h (includes pre-lecture material), 2 group assignments 25h + 25h = 50h, and one individual work 33h. The work hours for lectures provide students time to prepare for lectures and to discuss them afterwards. Assignments consist of working in groups.

- **Learning Outcomes:** Interested in managing ICT ventures? Want to free your mind from management preconceptions? The course provides a holistic picture of what entrepreneurs and managers of ICT ventures need to consider when establishing, developing and running their businesses. The course covers: the general processes and roles involved in developing ideas and starting up a new technology-based company or business business organization and projects
- product and process development in ICT business
- financing new businesses
- managing and developing human resources and venture capabilities
- value creation and capture, intellectual property
- and other important elements in managing a technology venture.

Lectures include insights from case studies of real firms, and first-hand experiences from industry guest lecturers.

Content: The course covers the entrepreneurial steps from the partner search and idea generation to the financing rounds and fast growth. The focus is on technology-based entrepreneurship and venture management. The course includes lectures and case studies on real high technology firms, ICT trends, business ecosystems and markets, organization and project management, new product and process development, entrepreneurial finance and human resource development. Tools for e.g. work personality test and competency assessment are available (optional to be used in individual work). The guest lecturers, content, and the case studies vary.

Assessment Methods and Criteria: This course is assessed based on two group assignments maximum 20 points (10 each), and one individual work max 10 points. Maximum point score for the course is 30. Minimum total points required to pass the course is 15. Minimum for passing each group assignment and the individual work is 5 points. There is an optional exam.

Study Material: Lecture material, selected journal and practitioner articles, complementary materials. Materials vary from year to year, and are announced during the lectures.

Substitutes for Courses: Replaces former course CSE-E4755 Management of a Technology Venture (6 op).

Prerequisites: CS-E5100 / CSE-E4751 Introduction to IT Business and Venturing, or similar knowledge.

Grading Scale: 0-5

Language of Instruction: English

Further Information: The number of participants may be limited to 60 students. Registrations will be prioritized in the following order: The students that have the course as a mandatory part of their study program will be prioritized first. The students that are participating in the Aalto Ventures Program minor will be prioritized second. After this, all students are prioritized based on registration

order.

CS-E5200 Design Project (10 cr)

Responsible teacher: Mika Nieminen; Marko Nieminen; Marjo Kauppinen; Carl Mitts
Status of the Course: Compulsory course of the Software and Service Engineering major (SDE track), Information networks major (UCD track) and ICT Innovation major (HCID track).
Level of the Course: Master's level
Teaching period: III - V
Workload: Lectures 27h (9x3h), workshops 24h (3x8h), group work 180h and pitching sessions 36h (9x4h).
Learning Outcomes: After the course, you will be able to understand and explain the user centered design process for digital services. You can select and apply the correct tools and methods for the various phases of the process. You learn to apply the acquired user knowledge to solve a real-life design problem. You gain insight and experience on how to analyze and evaluate the intermediate design deliverables in an iterative design process. You will know how to present the designs and argue your design decisions in a clear and concise form. You will acquire industry best practices for product and service design with the ability to adapt them to your specific needs.
Content: This course teaches the overall process and practices of user-centered design of digital products and services. The students' projects produce interactive prototypes starting from the scratch. The course has a hands on learning-by-doing approach with strong industry participation (tutoring).
Assessment Methods and Criteria: Assessment is based on the group effort and all members receive the same grade . Each intermediate pitching session is graded 0-5, the final grade is the arithmetic mean of all scores. An extraordinarily excellent final presentation and prototype may raise the grade by 1.
Study Material: Lecture materials, selected journal and practitioner articles and complementary materials. Materials are announced in course web site.
Substitutes for Courses: Replaces the former courses CSE-E5888 Design Project, T-121.5350 Strategic User-Centred Design and T-106.5750 Aalto Service Camp.
Prerequisites: CS-E4900 / CSE-E5800 User-Centered Methods for Product and Service Design.
Evaluation: 0-5, may be graded with pass/fail
Registration for Courses: Enrollment in WebOodi.
Language of Instruction: English
Further Information:
The number of participants will be limited (60). Registrations will be prioritized in the following order:
1) The students that have the course as a mandatory part in SSE, Information Networks, ICT Innovation, and uSchool majors,
2) The students that have the course as a mandatory part in SSE, Information Networks, ICT Innovation, and uSchool minors,

3) The students that have the course as an elective part of their major,
4) The students that have the course as an elective part of their minor, and
5) All other students based on registration order.

CS-E5200 Design Project (10 sp)

Ansvarig lärare: Mika Nieminen; Marko Nieminen; Marjo Kauppinen; Carl Mitts
Kursens status: Compulsory course of the Software and Service Engineering major (SDE track), Information networks major (UCD track) and ICT Innovation major (HCID track).
Kursnivå: Master's level
Undervisningsperiod: III - V
Arbetsmängd: Lectures 27h (9x3h), workshops 24h (3x8h), group work 180h and pitching sessions 36h (9x4h).
Lärandemål: After the course, you will be able to understand and explain the user centered design process for digital services. You can select and apply the correct tools and methods for the various phases of the process. You learn to apply the acquired user knowledge to solve a real-life design problem. You gain insight and experience on how to analyze and evaluate the intermediate design deliverables in an iterative design process. You will know how to present the designs and argue your design decisions in a clear and concise form. You will acquire industry best practices for product and service design with the ability to adapt them to your specific needs.
Innehåll: This course teaches the overall process and practices of user-centered design of digital products and services. The students' projects produce interactive prototypes starting from the scratch. The course has a hands on learning-by-doing approach with strong industry participation (tutoring).
Metoder, arbetssätt och bedömningsgrunder: Assessment is based on the group effort and all members receive the same grade . Each intermediate pitching session is graded 0-5, the final grade is the arithmetic mean of all scores. An extraordinarily excellent final presentation and prototype may raise the grade by 1.
Studiematerial: Lecture materials, selected journal and practitioner articles and complementary materials. Materials are announced in course web site.
Ersättande prestationer: Replaces the former courses CSE-E5888 Design Project, T-121.5350 Strategic User-Centred Design and T-106.5750 Aalto Service Camp.
Förkunskaper: CS-E4900 / CSE-E5800 User-Centered Methods for Product and Service Design.
Bedömningsskala: 0-5, may be graded with pass/fail
Anmälning: Enrollment in WebOodi.
Undervisningsspråk: English
Tilläggsinformation:
The number of participants will be limited (60). Registrations will be prioritized in the following order:
1) The students that have the course as a mandatory part in SSE, Information

Networks, ICT Innovation, and uSchool majors,
2) The students that have the course as a mandatory part in SSE, Information Networks, ICT Innovation, and uSchool minors,
3) The students that have the course as an elective part of their major,
4) The students that have the course as an elective part of their minor, and
5) All other students based on registration order.

CS-E5200 Design Project (10 cr)

Responsible teacher: Mika Nieminen; Marko Nieminen; Marjo Kauppinen; Carl Mitts
Status of the Course: Compulsory course of the Software and Service Engineering major (SDE track), Information networks major (UCD track) and ICT Innovation major (HCID track).
Level of the Course: Master's level
Teaching Period: III - V
Workload: Lectures 27h (9x3h), workshops 24h (3x8h), group work 180h and pitching sessions 36h (9x4h).
Learning Outcomes: After the course, you will be able to understand and explain the user centered design process for digital services. You can select and apply the correct tools and methods for the various phases of the process. You learn to apply the acquired user knowledge to solve a real-life design problem. You gain insight and experience on how to analyze and evaluate the intermediate design deliverables in an iterative design process. You will know how to present the designs and argue your design decisions in a clear and concise form. You will acquire industry best practices for product and service design with the ability to adapt them to your specific needs.
Content: This course teaches the overall process and practices of user-centered design of digital products and services. The students' projects produce interactive prototypes starting from the scratch. The course has a hands on learning-by-doing approach with strong industry participation (tutoring).
Assessment Methods and Criteria: Assessment is based on the group effort and all members receive the same grade . Each intermediate pitching session is graded 0-5, the final grade is the arithmetic mean of all scores. An extraordinarily excellent final presentation and prototype may raise the grade by 1.
Study Material: Lecture materials, selected journal and practitioner articles and complementary materials. Materials are announced in course web site.
Substitutes for Courses: Replaces the former courses CSE-E5888 Design Project, T-121.5350 Strategic User-Centred Design and T-106.5750 Aalto Service Camp.
Prerequisites: CS-E4900 / CSE-E5800 User-Centered Methods for Product and Service Design.
Grading Scale: 0-5, may be graded with pass/fail
Registration for Courses: Enrollment in WebOodi.
Language of Instruction: English
Further Information:
The number of participants will be limited (60). Registrations will be prioritized

in the following order:
1) The students that have the course as a mandatory part in SSE, Information Networks, ICT Innovation, and uSchool majors,
2) The students that have the course as a mandatory part in SSE, Information Networks, ICT Innovation, and uSchool minors,
3) The students that have the course as an elective part of their major,
4) The students that have the course as an elective part of their minor, and
5) All other students based on registration order.

CS-E5210 Usability evaluation (5 cr)

Responsible teacher: Johanna Kaipio; Marko Nieminen
Status of the Course: Compulsory course of the Software and Service Engineering major (UCD track) and ICT Innovation major (HCID track).
Level of the Course: Master's level
Teaching period: IV – V (Spring)
Workload: Lectures and presentations 30h, tutoring 10h, individual assignments + exam 20h, project work 75h.
Learning Outcomes: After the course, you can select suitable usability evaluation methods in various situations, and to argument your choices. You are able to design and carry out usability evaluations, and to communicate your results to customers in order to have an impact on further development.
Content: The course introduces several usability evaluation methods including both usability inspection and user testing methods. The methods are applied in project works conducted in cooperation with companies aiming at an improved prototype of the evaluated system.
Assessment Methods and Criteria: Group work (60%) and individual assignments & exam (40%).
Study Material: Lecture materials, selected journal and practitioner articles and complementary materials. Materials are announced in course web site.
Substitutes for Courses: Replaces the courses CSE-E5810 Usability Evaluation, T-121.5450 Interaction Design and Evaluation.
Prerequisites: CS-E4900 / CSE-E5800 User-Centred Methods for Product and Service or equivalent knowledge in user-centred design and usability.
Evaluation: 0-5, may be graded with pass/fail
Registration for Courses: Enrollment in WebOodi.
Language of Instruction: English
Further Information:
The number of participants will be limited (25). Registrations will be prioritized in the following order:
1) The students that have the course as a mandatory part in SSE, Information Networks, ICT Innovation, and uSchool majors,
2) The students that have the course as a mandatory part in SSE, Information Networks, ICT Innovation, and uSchool minors,
3) The students that have the course as an elective part of their major,
4) The students that have the course as an elective part of their minor, and
5) All other students based on registration order.

CS-E5210 Usability evaluation (5 sp)

Ansvarig lärare: Johanna Kaipio; Marko Nieminen
Kursens status: Compulsory course of the Software and Service Engineering major (UCD track) and ICT Innovation major (HCID track).
Kursnivå: Master's level
Undervisningsperiod: IV – V (Spring)
Arbetsmängd: Lectures and presentations 30h, tutoring 10h, individual assignments + exam 20h, project work 75h.
Lärandemål: After the course, you can select suitable usability evaluation methods in various situations, and to argument your choices. You are able to design and carry out usability evaluations, and to communicate your results to customers in order to have an impact on further development.
Innehåll: The course introduces several usability evaluation methods including both usability inspection and user testing methods. The methods are applied in project works conducted in cooperation with companies aiming at an improved prototype of the evaluated system.
Metoder, arbetssätt och bedömningsgrunder: Group work (60%) and individual assignments & exam (40%).
Studiematerial: Lecture materials, selected journal and practitioner articles and complementary materials. Materials are announced in course web site.
Ersättande prestationer: Replaces the courses CSE-E5810 Usability Evaluation, T-121.5450 Interaction Design and Evaluation.
Förkunskaper: CS-E4900 / CSE-E5800 User-Centred Methods for Product and Service or equivalent knowledge in user-centred design and usability.
Bedömningsskala: 0-5, may be graded with pass/fail
Anmälning: Enrollment in WebOodi.
Undervisningsspråk: English
Tilläggsinformation:
The number of participants will be limited (25). Registrations will be prioritized in the following order:
1) The students that have the course as a mandatory part in SSE, Information Networks, ICT Innovation, and uSchool majors,
2) The students that have the course as a mandatory part in SSE, Information Networks, ICT Innovation, and uSchool minors,
3) The students that have the course as an elective part of their major,
4) The students that have the course as an elective part of their minor, and
5) All other students based on registration order.

CS-E5210 Usability evaluation (5 cr)

Responsible teacher: Johanna Kaipio; Marko Nieminen
Status of the Course: Compulsory course of the Software and Service Engineering major (UCD track) and ICT Innovation major (HCID track).
Level of the Course: Master's level
Teaching Period: IV – V (Spring)
Workload: Lectures and presentations 30h, tutoring 10h, individual assignments

+ exam 20h, project work 75h.
Learning Outcomes: After the course, you can select suitable usability evaluation methods in various situations, and to argument your choices. You are able to design and carry out usability evaluations, and to communicate your results to customers in order to have an impact on further development.
Content: The course introduces several usability evaluation methods including both usability inspection and user testing methods. The methods are applied in project works conducted in cooperation with companies aiming at an improved prototype of the evaluated system.
Assessment Methods and Criteria: Group work (60%) and individual assignments & exam (40%).
Study Material: Lecture materials, selected journal and practitioner articles and complementary materials. Materials are announced in course web site.
Substitutes for Courses: Replaces the courses CSE-E5810 Usability Evaluation, T-121.5450 Interaction Design and Evaluation.
Prerequisites: CS-E4900 / CSE-E5800 User-Centred Methods for Product and Service or equivalent knowledge in user-centred design and usability.
Grading Scale: 0-5, may be graded with pass/fail
Registration for Courses: Enrollment in WebOodi.
Language of Instruction: English
Further Information:
The number of participants will be limited (25). Registrations will be prioritized in the following order:
1) The students that have the course as a mandatory part in SSE, Information Networks, ICT Innovation, and uSchool majors,
2) The students that have the course as a mandatory part in SSE, Information Networks, ICT Innovation, and uSchool minors,
3) The students that have the course as an elective part of their major,
4) The students that have the course as an elective part of their minor, and
5) All other students based on registration order.

CS-E5220 User Interface Construction (5 cr)

Responsible teacher: Marko Nieminen
Status of the Course: Compulsory course of the Software and Service Engineering major (UCD track).
Level of the Course: Master's level
Teaching period: II
Workload: Lectures 22h, group tutoring 3h, group work 90h, independent work 20h
Learning Outcomes: At this course the students learn user interface and interaction design. After completing the course, students are able to develop an interactive user interface that can be used for usability testing. Students know how to use user-centred principles, guidelines and patterns in the design and implementation of user interfaces.
Content: The design and construction of user interfaces. Use of basic user interface elements and style guides.

Assessment Methods and Criteria: Lectures and examination, exercises.
Study Material: Materials are announced in course web site.
Substitutes for Courses: Replaces former course CSE-E5820 / T-121.5300 User interface construction.
Prerequisites: CS-C3120 Human-computer Interaction / CSE-C3800 User Interfaces and Usability or equivalent basics in user-centred design and usability.
Evaluation: 0-5, may be graded with pass/fail
Registration for Courses: Enrollment in WebOodi.
Language of Instruction: English
Further Information:
The number of participants will be limited (100). Registrations will be prioritized in the following order:
1) The students that have the course as a mandatory part in SSE, Information Networks, ICT Innovation, and uSchool majors,
2) The students that have the course as a mandatory part in SSE, Information Networks, ICT Innovation, and uSchool minors,
3) The students that have the course as an elective part of their major,
4) The students that have the course as an elective part of their minor, and
5) All other students based on registration order.

CS-E5220 User Interface Construction (5 sp)

Ansvarig lärare: Marko Nieminen
Kursens status: Compulsory course of the Software and Service Engineering major (UCD track).
Kursnivå: Master's level
Undervisningsperiod: II
Arbetsmängd: Lectures 22h, group tutoring 3h, group work 90h, independent work 20h
Lärandemål: At this course the students learn user interface and interaction design. After completing the course, students are able to develop an interactive user interface that can be used for usability testing. Students know how to use user-centred principles, guidelines and patterns in the design and implementation of user interfaces.
Innehåll: The design and construction of user interfaces. Use of basic user interface elements and style guides.
Metoder, arbetssätt och bedömningsgrunder: Lectures and examination, exercises.
Studiematerial: Materials are announced in course web site.
Ersättande prestationer: Replaces former course CSE-E5820 / T-121.5300 User interface construction.
Förkunskaper: CS-C3120 Human-computer Interaction / CSE-C3800 User Interfaces and Usability or equivalent basics in user-centred design and usability.
Bedömningsskala: 0-5, may be graded with pass/fail
Anmälning: Enrollment in WebOodi.
Undervisningsspråk: English
Tilläggsinformation:

The number of participants will be limited (100). Registrations will be prioritized in the following order:
1) The students that have the course as a mandatory part in SSE, Information Networks, ICT Innovation, and uSchool majors,
2) The students that have the course as a mandatory part in SSE, Information Networks, ICT Innovation, and uSchool minors,
3) The students that have the course as an elective part of their major,
4) The students that have the course as an elective part of their minor, and
5) All other students based on registration order.

CS-E5220 User Interface Construction (5 cr)

Responsible teacher: Marko Nieminen
Status of the Course: Compulsory course of the Software and Service Engineering major (UCD track).
Level of the Course: Master's level
Teaching Period: II
Workload: Lectures 22h, group tutoring 3h, group work 90h, independent work 20h
Learning Outcomes: At this course the students learn user interface and interaction design. After completing the course, students are able to develop an interactive user interface that can be used for usability testing. Students know how to use user-centred principles, guidelines and patterns in the design and implementation of user interfaces.
Content: The design and construction of user interfaces. Use of basic user interface elements and style guides.
Assessment Methods and Criteria: Lectures and examination, exercises.
Study Material: Materials are announced in course web site.
Substitutes for Courses: Replaces former course CSE-E5820 / T-121.5300 User interface construction.
Prerequisites: CS-C3120 Human-computer Interaction / CSE-C3800 User Interfaces and Usability or equivalent basics in user-centred design and usability.
Grading Scale: 0-5, may be graded with pass/fail
Registration for Courses: Enrollment in WebOodi.
Language of Instruction: English
Further Information:
The number of participants will be limited (100). Registrations will be prioritized in the following order:
1) The students that have the course as a mandatory part in SSE, Information Networks, ICT Innovation, and uSchool majors,
2) The students that have the course as a mandatory part in SSE, Information Networks, ICT Innovation, and uSchool minors,
3) The students that have the course as an elective part of their major,
4) The students that have the course as an elective part of their minor, and
5) All other students based on registration order.

CS-E5300 Enterprise Systems Architecture (5 cr)

Responsible teacher: Martti Mäntylä; Kari Hiekkanen
Status of the Course: Compulsory course of the Enterprise Systems track in Software and Service Engineering major.
Level of the Course: Master's level
Teaching period: I (Autumn)
Workload: Lectures, assignments and exam.
Learning Outcomes: After the course you understand of the role of technology and information systems (IS) within an enterprise context, understand the concepts of the core business processes their relationship to information systems, understand the role of and the need for an enterprise architecture.
Content: Introduction to the roles of information in general and different information systems in particular within an enterprise context, the fundamentals of an an enterprise architecture, its management and governance. The core information systems of an enterprise, such as enterprise resource planning (ERP), customer relationship management (CRM), data warehousing (DW), business intelligence (BI), product data management (PDM), enterprise content management (ECM). The course covers both theory and relevant practical examples from different enterprises and industry sectors.
Assessment Methods and Criteria: Lectures, assignments and examination.
Study Material: Agreed separately.
Substitutes for Courses: Replaces former courses CSE-E4650 / T-86.5141 Enterprise Systems Architecture
Evaluation: 0-5
Registration for Courses: Registration via WebOodi.
Language of Instruction: English
Further Information:
The number of participants will be limited (100). Registrations will be prioritized in the following order:
1) the students of CCIS / SSE major;
2) students that have the course as a mandatory or elective part of their major or minor;
3) all other students based on registration order.

CS-E5300 Enterprise Systems Architecture (5 sp)

Ansvarig lärare: Martti Mäntylä; Kari Hiekkanen
Kursens status: Compulsory course of the Enterprise Systems track in Software and Service Engineering major.
Kursnivå: Master's level
Undervisningsperiod: I (Autumn)
Arbetsmängd: Lectures, assignments and exam.
Lärandemål: After the course you understand of the role of technology and information systems (IS) within an enterprise context, understand the concepts of the core business processes their relationship to information systems, understand the role of and the need for an enterprise architecture.
Innehåll: Introduction to the roles of information in general and different information systems in particular within an enterprise context, the fundamentals

of an an enterprise architecture, its management and governance. The core information systems of an enterprise, such as enterprise resource planning (ERP), customer relationship management (CRM), data warehousing (DW), business intelligence (BI), product data management (PDM), enterprise content management (ECM). The course covers both theory and relevant practical examples from different enterprises and industry sectors.
Metoder, arbetssätt och bedömningsgrunder: Lectures, assignments and examination.
Studiematerial: Agreed separately.
Ersättande prestationer: Replaces former courses CSE-E4650 / T-86.5141 Enterprise Systems Architecture
Bedömningsskala: 0-5
Anmälning: Registration via WebOodi.
Undervisningsspråk: English
Tilläggsinformation:
The number of participants will be limited (100). Registrations will be prioritized in the following order:
1) the students of CCIS / SSE major;
2) students that have the course as a mandatory or elective part of their major or minor;
3) all other students based on registration order.

CS-E5300 Enterprise Systems Architecture (5 cr)

Responsible teacher: Martti Mäntylä; Kari Hiekkanen
Status of the Course: Compulsory course of the Enterprise Systems track in Software and Service Engineering major.
Level of the Course: Master's level
Teaching Period: I (Autumn)
Workload: Lectures, assignments and exam.
Learning Outcomes: After the course you understand of the role of technology and information systems (IS) within an enterprise context, understand the concepts of the core business processes their relationship to information systems, understand the role of and the need for an enterprise architecture.
Content: Introduction to the roles of information in general and different information systems in particular within an enterprise context, the fundamentals of an an enterprise architecture, its management and governance. The core information systems of an enterprise, such as enterprise resource planning (ERP), customer relationship management (CRM), data warehousing (DW), business intelligence (BI), product data management (PDM), enterprise content management (ECM). The course covers both theory and relevant practical examples from different enterprises and industry sectors.
Assessment Methods and Criteria: Lectures, assignments and examination.
Study Material: Agreed separately.
Substitutes for Courses: Replaces former courses CSE-E4650 / T-86.5141 Enterprise Systems Architecture
Grading Scale: 0-5

Registration for Courses: Registration via WebOodi.
Language of Instruction: English
Further Information:
The number of participants will be limited (100). Registrations will be prioritized in the following order:
1) the students of CCIS / SSE major;
2) students that have the course as a mandatory or elective part of their major or minor;
3) all other students based on registration order.

CS-E5310 ICT Enabled Service Business and Innovation (5 cr)

Responsible teacher: Martti Mäntylä; Mikko Heiskala
Status of the Course: Compulsory course in the Enterprise Systems track in Software and Service Engineering major and Service Design and Engineering track in the EIT ICT Innovation major. Optional course in the Service Design and Engineering track in Software and Service Engineering major, Information Networks major, and Aalto Service Minor.
Level of the Course: Master's level
Teaching period: I-II (lectures begin most likely on fifth week of period I; check course web pages for confirmation)
Workload: Lectures 30h + Lecture self-reflection 30h Preparation for lectures (e.g. pre-reading) 27,5h
Weekly assignments (min 5) OR exam preparation 50h Total 137,5h
Learning Outcomes: After the course you'll understand the role of ICT and software in driving service business and innovation and can use theoretical concepts to analyse real world ICT enabled services. You will also become familiar with current trends that drive digital service business and innovation.
Content: A high-level view to digitalisation and servitisation of economy, industries, and companies. How ICT affects service business and innovation. Platforms, ecosystems, two-sided markets and other relevant concepts for understanding ICT enabled digital service business and innovation. Current topics and trends driving innovation in ICT enabled services business. Visiting case lectures from industry, startups, and Aalto University research illustrating the theoretical content of the course in practice.
Assessment Methods and Criteria: Participation in lectures (pass/fail), weekly assignments total grade (0-5) OR exam (0-5). Check course web pages for confirmed details before course begins (e.g. lecture participation limit; it'll be around 50%-60%).
Study Material: Lectures and collection of articles delivered on the course web pages.
Substitutes for Courses: Replaces course CSE-E4660 / T-86.5310 ICT Enabled Service Business and Innovation (and its predecessor T-86.5300 Information and Communication Technology Enabled Commerce).
Prerequisites: No prerequisites but basic knowledge of IT business and information systems concepts and TU-E2000 Aalto Introduction to Services are recommended.

Evaluation: 0-5
Registration for Courses: Via WebOodi
Language of Instruction: English
Further Information:
The course is open for Aalto students. The number of participants will be limited (80). Registrations will be prioritized in the following order:
1) the students of CCIS / SSE major;
2) students that have the course as a mandatory or elective part of their major or minor;
3) all other students based on registration order. Minor changes to the course information is possible. Check the course web pages before the course begins.

CS-E5310 ICT Enabled Service Business and Innovation (5 sp)

Ansvarig lärare: Martti Mäntylä; Mikko Heiskala
Kursens status: Compulsory course in the Enterprise Systems track in Software and Service Engineering major and Service Design and Engineering track in the EIT ICT Innovation major. Optional course in the Service Design and Engineering track in Software and Service Engineering major, Information Networks major, and Aalto Service Minor.
Kursnivå: Master's level
Undervisningsperiod: I-II (lectures begin most likely on fifth week of period I; check course web pages for confirmation)
Arbetsmängd: Lectures 30h + Lecture self-reflection 30h Preparation for lectures (e.g. pre-reading) 27,5h
Weekly assignments (min 5) OR exam preparation 50h Total 137,5h
Lärandemål: After the course you'll understand the role of ICT and software in driving service business and innovation and can use theoretical concepts to analyse real world ICT enabled services. You will also become familiar with current trends that drive digital service business and innovation.
Innehåll: A high-level view to digitalisation and servitisation of economy, industries, and companies. How ICT affects service business and innovation. Platforms, ecosystems, two-sided markets and other relevant concepts for understanding ICT enabled digital service business and innovation. Current topics and trends driving innovation in ICT enabled services business. Visiting case lectures from industry, startups, and Aalto University research illustrating the theoretical content of the course in practice.
Metoder, arbetssätt och bedömningsgrunder: Participation in lectures (pass/fail), weekly assignments total grade (0-5) OR exam (0-5). Check course web pages for confirmed details before course begins (e.g. lecture participation limit; it'll be around 50%-60%).
Studiematerial: Lectures and collection of articles delivered on the course web pages.
Ersättande prestationer: Replaces course CSE-E4660 / T-86.5310 ICT Enabled Service Business and Innovation (and its predecessor T-86.5300 Information and Communication Technology Enabled Commerce).
Förkunskaper: No prerequisites but basic knowledge of IT business and

information systems concepts and TU-E2000 Aalto Introduction to Services are recommended.
Bedömningsskala: 0-5
Anmälning: Via WebOodi
Undervisningsspråk: English
Tilläggsinformation:
The course is open for Aalto students. The number of participants will be limited (80). Registrations will be prioritized in the following order:
1) the students of CCIS / SSE major;
2) students that have the course as a mandatory or elective part of their major or minor;
3) all other students based on registration order. Minor changes to the course information is possible. Check the course web pages before the course begins.

CS-E5310 ICT Enabled Service Business and Innovation (5 cr)

Responsible teacher: Martti Mäntylä; Mikko Heiskala
Status of the Course: Compulsory course in the Enterprise Systems track in Software and Service Engineering major and Service Design and Engineering track in the EIT ICT Innovation major. Optional course in the Service Design and Engineering track in Software and Service Engineering major, Information Networks major, and Aalto Service Minor.
Level of the Course: Master's level
Teaching Period: I-II (lectures begin most likely on fifth week of period I; check course web pages for confirmation)
Workload: Lectures 30h + Lecture self-reflection 30h Preparation for lectures (e.g. pre-reading) 27,5h
Weekly assignments (min 5) OR exam preparation 50h Total 137,5h
Learning Outcomes: After the course you'll understand the role of ICT and software in driving service business and innovation and can use theoretical concepts to analyse real world ICT enabled services. You will also become familiar with current trends that drive digital service business and innovation.
Content: A high-level view to digitalisation and servitisation of economy, industries, and companies. How ICT affects service business and innovation. Platforms, ecosystems, two-sided markets and other relevant concepts for understanding ICT enabled digital service business and innovation. Current topics and trends driving innovation in ICT enabled services business. Visiting case lectures from industry, startups, and Aalto University research illustrating the theoretical content of the course in practice.
Assessment Methods and Criteria: Participation in lectures (pass/fail), weekly assignments total grade (0-5) OR exam (0-5). Check course web pages for confirmed details before course begins (e.g. lecture participation limit; it'll be around 50%-60%).
Study Material: Lectures and collection of articles delivered on the course web pages.
Substitutes for Courses: Replaces course CSE-E4660 / T-86.5310 ICT Enabled Service Business and Innovation (and its predecessor T-86.5300 Information and

Communication Technology Enabled Commerce).
Prerequisites: No prerequisites but basic knowledge of IT business and information systems concepts and TU-E2000 Aalto Introduction to Services are recommended.
Grading Scale: 0-5
Registration for Courses: Via WebOodi
Language of Instruction: English
Further Information:
The course is open for Aalto students. The number of participants will be limited (80). Registrations will be prioritized in the following order:
1) the students of CCIS / SSE major;
2) students that have the course as a mandatory or elective part of their major or minor;
3) all other students based on registration order. Minor changes to the course information is possible. Check the course web pages before the course begins.

CS-E5320 Seminar on Enterprise Information Systems(V) (3-10 cr)

Responsible teacher: Martti Mäntylä; Kari Hiekkanen
Status of the Course: Optional course of the Enterprise Systems track in the Software and Service Engineering major.
Level of the Course: Master's level
Teaching period: (Arranged according to agreement)
Learning Outcomes: You understand topical issues related to Enterprise Information Systems (EIS), IT Governance, Enterprise Architecture (EA), and Business Informatics and Intelligence.
Content: The content of this course varies.
Assessment Methods and Criteria: Agreed separately.
Study Material: Agreed separately.
Substitutes for Courses: Replaces former courses CSE-E5650 / T-86.5165 Seminar on Enterprise Information Systems.
Prerequisites: CS-E5300 / CSE-E4650 Enterprise Systems Architecture, recommended CS-E5330 / CSE-E4655 IT Governance.
Evaluation: 0-5
Registration for Courses: Registration via WebOodi.
Language of Instruction: English
Further Information:
The number of participants will be limited (30). Registrations will be prioritized in the following order:
1) the students of CCIS / SSE major;
2) students that have the course as a mandatory or elective part of their major or minor;
3) all other students based on registration order.

CS-E5320 Seminar on Enterprise Information Systems(V) (3-10 sp)

Ansvarig lärare: Martti Mäntylä; Kari Hiekkanen
Kursens status: Optional course of the Enterprise Systems track in the Software

and Service Engineering major.
Kursnivå: Master's level
Undervisningsperiod: (Arranged according to agreement)
Lärandemål: You understand topical issues related to Enterprise Information Systems (EIS), IT Governance, Enterprise Architecture (EA), and Business Informatics and Intelligence.
Innehåll: The content of this course varies.
Metoder, arbetssätt och bedömningsgrunder: Agreed separately.
Studiematerial: Agreed separately.
Ersättande prestationer: Replaces former courses CSE-E5650 / T-86.5165 Seminar on Enterprise Information Systems.
Förkunskaper: CS-E5300 / CSE-E4650 Enterprise Systems Architecture, recommended CS-E5330 / CSE-E4655 IT Governance.
Bedömningsskala: 0-5
Anmälning: Registration via WebOodi.
Undervisningsspråk: English
Tilläggsinformation:
The number of participants will be limited (30). Registrations will be prioritized in the following order:
1) the students of CCIS / SSE major;
2) students that have the course as a mandatory or elective part of their major or minor;
3) all other students based on registration order.

CS-E5320 Seminar on Enterprise Information Systems(V) (3-10 cr)

Responsible teacher: Martti Mäntylä; Kari Hiekkanen
Status of the Course: Optional course of the Enterprise Systems track in the Software and Service Engineering major.
Level of the Course: Master's level
Teaching Period: (Arranged according to agreement)
Learning Outcomes: You understand topical issues related to Enterprise Information Systems (EIS), IT Governance, Enterprise Architecture (EA), and Business Informatics and Intelligence.
Content: The content of this course varies.
Assessment Methods and Criteria: Agreed separately.
Study Material: Agreed separately.
Substitutes for Courses: Replaces former courses CSE-E5650 / T-86.5165 Seminar on Enterprise Information Systems.
Prerequisites: CS-E5300 / CSE-E4650 Enterprise Systems Architecture, recommended CS-E5330 / CSE-E4655 IT Governance.
Grading Scale: 0-5
Registration for Courses: Registration via WebOodi.
Language of Instruction: English
Further Information:
The number of participants will be limited (30). Registrations will be prioritized in the following order:

1) the students of CCIS / SSE major;
2) students that have the course as a mandatory or elective part of their major or minor;
3) all other students based on registration order.

CS-E5330 IT Governance (5 cr)

Responsible teacher: Martti Mäntylä; Kari Hiekkanen
Status of the Course: Optional course of the Enterprise Systems track in Software and Service Engineering major.
Level of the Course: Master's level
Teaching period: II (Autumn)
Learning Outcomes: You understand the role of IS in organizations and fundamental concepts related to information technology governance and service management, remember the basics of the relevant frameworks and process models in the area.
Content: Different strategic approaches to usage and management of information in organizational contects. The fundamentals of IT Governance and IT Service Management. Current industry best practises and frameworks, such as ITIL, Cobit, ValIT.
Assessment Methods and Criteria: Agreed separately.
Study Material: Agreed separately.
Substitutes for Courses: Replaces former course CSE-E4655 / T-86.5180 IT Governance.
Prerequisites: CS-E5300 / CSE-E4650 Enterprise Systems Architecture or equivalent knowledge.
Evaluation: 0-5
Registration for Courses: Registration via WebOodi.
Language of Instruction: English
Further Information:
The number of participants will be limited (50). Registrations will be prioritized in the following order:
1) the students of CCIS / SSE major;
2) students that have the course as a mandatory or elective part of their major or minor;
3) all other students based on registration order.

CS-E5330 IT Governance (5 sp)

Ansvarig lärare: Martti Mäntylä; Kari Hiekkanen
Kursens status: Optional course of the Enterprise Systems track in Software and Service Engineering major.
Kursnivå: Master's level
Undervisningsperiod: II (Autumn)
Lärandemål: You understand the role of IS in organizations and fundamental concepts related to information technology governance and service management, remember the basics of the relevant frameworks and process models in the area.
Innehåll: Different strategic approaches to usage and management of information

in organizational contects. The fundamentals of IT Governance and IT Service Management. Current industry best practises and frameworks, such as ITIL, Cobit, ValIT.
Metoder, arbetssätt och bedömningsgrunder: Agreed separately.
Studiematerial: Agreed separately.
Ersättande prestationer: Replaces former course CSE-E4655 / T-86.5180 IT Governance.
Förkunskaper: CS-E5300 / CSE-E4650 Enterprise Systems Architecture or equivalent knowledge.
Bedömningsskala: 0-5
Anmälning: Registration via WebOodi.
Undervisningsspråk: English
Tilläggsinformation:
The number of participants will be limited (50). Registrations will be prioritized in the following order:
1) the students of CCIS / SSE major;
2) students that have the course as a mandatory or elective part of their major or minor;
3) all other students based on registration order.

CS-E5330 IT Governance (5 cr)

Responsible teacher: Martti Mäntylä; Kari Hiekkanen
Status of the Course: Optional course of the Enterprise Systems track in Software and Service Engineering major.
Level of the Course: Master's level
Teaching Period: II (Autumn)
Learning Outcomes: You understand the role of IS in organizations and fundamental concepts related to information technology governance and service management, remember the basics of the relevant frameworks and process models in the area.
Content: Different strategic approaches to usage and management of information in organizational contects. The fundamentals of IT Governance and IT Service Management. Current industry best practises and frameworks, such as ITIL, Cobit, ValIT.
Assessment Methods and Criteria: Agreed separately.
Study Material: Agreed separately.
Substitutes for Courses: Replaces former course CSE-E4655 / T-86.5180 IT Governance.
Prerequisites: CS-E5300 / CSE-E4650 Enterprise Systems Architecture or equivalent knowledge.
Grading Scale: 0-5
Registration for Courses: Registration via WebOodi.
Language of Instruction: English
Further Information:
The number of participants will be limited (50). Registrations will be prioritized in the following order:

1) the students of CCIS / SSE major;
2) students that have the course as a mandatory or elective part of their major or minor;
3) all other students based on registration order.

CS-E5340 Introduction to Industrial Internet (5 cr)

Responsible teacher: Martti Mäntylä
Status of the Course: Optional course of the Enterprise Systems track in Software and Service Engineering major.
Level of the Course: Master's level
Teaching period: IV (Spring)
Learning Outcomes: You learn about the general "big picture" of the Industrial Internet, its key technologies across the stack, and the opportunities it offers in various industrial domains.
Content: The course will cover the central topics of Industrial Internet, including: Basic concepts, Relevant technologies of the digitalization stack, Data modelling and analysis, - Topics of data integration, Application scenarios and business models, Management and human factors. The course consists of lectures with plentiful guest speakers from industry, giving practical case studies.
Assessment Methods and Criteria: Agreed separately.
Study Material: Agreed separately.
Substitutes for Courses: Replaces the former course CSE-E4670 Introduction to Industrial Internet.
Evaluation: 0-5
Registration for Courses: Registration via WebOodi.
Language of Instruction: English
Further Information:
The number of participants will be limited (100). Registrations will be prioritized in the following order:
1) the students of CCIS / SSE major;
2) students that have the course as a mandatory or elective part of their major or minor;
3) all other students based on registration order.

CS-E5340 Introduction to Industrial Internet (5 sp)

Ansvarig lärare: Martti Mäntylä
Kursens status: Optional course of the Enterprise Systems track in Software and Service Engineering major.
Kursnivå: Master's level
Undervisningsperiod: IV (Spring)
Lärandemål: You learn about the general "big picture" of the Industrial Internet, its key technologies across the stack, and the opportunities it offers in various industrial domains.
Innehåll: The course will cover the central topics of Industrial Internet, including: Basic concepts, Relevant technologies of the digitalization stack, Data modelling and analysis, - Topics of data integration, Application scenarios and business

models, Management and human factors. The course consists of lectures with plentiful guest speakers from industry, giving practical case studies.
Metoder, arbetssätt och bedömningsgrunder: Agreed separately.
Studiematerial: Agreed separately.
Ersättande prestationer: Replaces the former course CSE-E4670 Introduction to Industrial Internet.
Bedömningsskala: 0-5
Anmälning: Registration via WebOodi.
Undervisningsspråk: English
Tilläggsinformation:
The number of participants will be limited (100). Registrations will be prioritized in the following order:
1) the students of CCIS / SSE major;
2) students that have the course as a mandatory or elective part of their major or minor;
3) all other students based on registration order.

CS-E5340 Introduction to Industrial Internet (5 cr)

Responsible teacher: Martti Mäntylä
Status of the Course: Optional course of the Enterprise Systems track in Software and Service Engineering major.
Level of the Course: Master's level
Teaching Period: IV (Spring)
Learning Outcomes: You learn about the general "big picture" of the Industrial Internet, its key technologies across the stack, and the opportunities it offers in various industrial domains.
Content: The course will cover the central topics of Industrial Internet, including: Basic concepts, Relevant technologies of the digitalization stack, Data modelling and analysis, - Topics of data integration, Application scenarios and business models, Management and human factors. The course consists of lectures with plentiful guest speakers from industry, giving practical case studies.
Assessment Methods and Criteria: Agreed separately.
Study Material: Agreed separately.
Substitutes for Courses: Replaces the former course CSE-E4670 Introduction to Industrial Internet.
Grading Scale: 0-5
Registration for Courses: Registration via WebOodi.
Language of Instruction: English
Further Information:
The number of participants will be limited (100). Registrations will be prioritized in the following order:
1) the students of CCIS / SSE major;
2) students that have the course as a mandatory or elective part of their major or minor;
3) all other students based on registration order.

CS-E5350 Industrial Internet Project(V) (5-10 cr)

Responsible teacher: Martti Mäntylä
Status of the Course: Optional course of the Enterprise Systems track in the Software and Service Engineering major.
Level of the Course: Master's level
Teaching period: I-V
Learning Outcomes: You will learn to apply the core technologies of Industrial Internet (sensors, actuators, embedded computing, communications, Internet and cloud technologies, ...) in a constructive project where a "smart product" or "smart system" is developed by a cross-disciplinary team of students from various Schools of Aalto.
Content: The course mainly consists of independent work in a teams of 6-8 students from various schools of the university (SCI, ENG, ELEC). Each team is expected to construct a "smart product" / "smart system" on the basis of an assigned topic with industrial relevance and demonstrate its operation. Apart from technical skills, good command of project methods and group work are developed. The course may also include tutorial sessions on specific development tools and technologies.
Assessment Methods and Criteria: Agreed separately.
Study Material: Agreed separately.
Substitutes for Courses: Replaces the former course CSE-E5675 Industrial Internet Project.
Prerequisites: CS-E5340 / CSE-E4670 Introduction to Industrial Internet or equivalent knowledge.
Evaluation: 0-5
Registration for Courses: Registration via WebOodi.
Language of Instruction: English
Further Information:
The number of participants will be limited (30). Registrations will be prioritized in the following order:
1) the students of CCIS / SSE major;
2) students that have the course as a mandatory or elective part of their major or minor;
3) all other students based on registration order.
The content of the course varies.

CS-E5350 Industrial Internet Project(V) (5-10 sp)

Ansvarig lärare: Martti Mäntylä
Kursens status: Optional course of the Enterprise Systems track in the Software and Service Engineering major.
Kursnivå: Master's level
Undervisningsperiod: I-V
Lärandemål: You will learn to apply the core technologies of Industrial Internet (sensors, actuators, embedded computing, communications, Internet and cloud technologies, ...) in a constructive project where a "smart product" or "smart system" is developed by a cross-disciplinary team of students from various

Schools of Aalto.
Innehåll: The course mainly consists of independent work in a teams of 6-8 students from various schools of the university (SCI, ENG, ELEC). Each team is expected to construct a “smart product” / “smart system” on the basis of an assigned topic with industrial relevance and demonstrate its operation. Apart from technical skills, good command of project methods and group work are developed. The course may also include tutorial sessions on specific development tools and technologies.
Metoder, arbetssätt och bedömningsgrunder: Agreed separately.
Studiematerial: Agreed separately.
Ersättande prestationer: Replaces the former course CSE-E5675 Industrial Internet Project.
Förkunskaper: CS-E5340 / CSE-E4670 Introduction to Industrial Internet or equivalent knowledge.
Bedömningsskala: 0-5
Anmälning: Registration via WebOodi.
Undervisningsspråk: English
Tilläggsinformation:
The number of participants will be limited (30). Registrations will be prioritized in the following order:
1) the students of CCIS / SSE major;
2) students that have the course as a mandatory or elective part of their major or minor;
3) all other students based on registration order.
The content of the course varies.

CS-E5350 Industrial Internet Project(V) (5-10 cr)

Responsible teacher: Martti Mäntylä
Status of the Course: Optional course of the Enterprise Systems track in the Software and Service Engineering major.
Level of the Course: Master’s level
Teaching Period: I-V
Learning Outcomes: You will learn to apply the core technologies of Industrial Internet (sensors, actuators, embedded computing, communications, Internet and cloud technologies, ...) in a constructive project where a “smart product” or “smart system” is developed by a cross-disciplinary team of students from various Schools of Aalto.
Content: The course mainly consists of independent work in a teams of 6-8 students from various schools of the university (SCI, ENG, ELEC). Each team is expected to construct a “smart product” / “smart system” on the basis of an assigned topic with industrial relevance and demonstrate its operation. Apart from technical skills, good command of project methods and group work are developed. The course may also include tutorial sessions on specific development tools and technologies.
Assessment Methods and Criteria: Agreed separately.
Study Material: Agreed separately.

Substitutes for Courses: Replaces the former course CSE-E5675 Industrial Internet Project.
Prerequisites: CS-E5340 / CSE-E4670 Introduction to Industrial Internet or equivalent knowledge.
Grading Scale: 0-5
Registration for Courses: Registration via WebOodi.
Language of Instruction: English
Further Information:
The number of participants will be limited (30). Registrations will be prioritized in the following order:
1) the students of CCIS / SSE major;
2) students that have the course as a mandatory or elective part of their major or minor;
3) all other students based on registration order.
The content of the course varies.

CS-E5360 Systems of Systems (5 cr)

Responsible teacher: Kary Främling
Level of the Course: Master's level
Teaching period: V
Learning Outcomes: You will learn how to build multi-organizational applications that utilize data from Internet of Things sources (mobile, personal devices etc) as well as Industrial Internet sources (manufacturing systems, maintenance systems, ...), Web sources (weather forecasts, energy prices, ...). You will also learn how to enable "intelligent control" between those systems, thereby building "System of Systems" applications.
Content: Hands-on examples and real systems will be studied, Systems of Systems architectures will be drafted for different application domains. Concepts such as Green Information Systems, Closed-Loop Lifecycle Management, Total Cost of Ownership and Fleet Management are key concepts for the achievable benefits from Systems of Systems. The main scope of the course is on architecting Information System Architectures for "Big Systems; however, business aspects, as well as societal and environmental aspects of such systems will be considered.
Assessment Methods and Criteria: Project work, examination
Substitutes for Courses: Replaces the former course CSE-E4675 Systems of Systems
Evaluation: 0-5
Registration for Courses: Registration via WebOodi. Please see WebOodi for registration dates.
Language of Instruction: English
Further Information: English

CS-E5360 Systems of Systems (5 sp)

Ansvarig lärare: Kary Främling
Kursnivå: Master's level
Undervisningsperiod: V

Lärandemål: You will learn how to build multi-organizational applications that utilize data from Internet of Things sources (mobile, personal devices etc) as well as Industrial Internet sources (manufacturing systems, maintenance systems, ...), Web sources (weather forecasts, energy prices, ...). You will also learn how to enable “intelligent control” between those systems, thereby building “System of Systems” applications.
Innehåll: Hands-on examples and real systems will be studied, Systems of Systems architectures will be drafted for different application domains. Concepts such as Green Information Systems, Closed-Loop Lifecycle Management, Total Cost of Ownership and Fleet Management are key concepts for the achievable benefits from Systems of Systems. The main scope of the course is on architecting Information System Architectures for “Big Systems; however, business aspects, as well as societal and environmental aspects of such systems will be considered.
Metoder, arbetssätt och bedömningsgrunder: Project work, examination
Ersättande prestationer: Replaces the former course CSE-E4675 Systems of Systems
Bedömningsskala: 0-5
Anmälning: Registration via WebOodi. Please see WebOodi for registration dates.
Undervisningsspråk: English

CS-E5360 Systems of Systems (5 cr)

Responsible teacher: Kary Främling
Level of the Course: Master’s level
Teaching Period: V
Learning Outcomes: You will learn how to build multi-organizational applications that utilize data from Internet of Things sources (mobile, personal devices etc) as well as Industrial Internet sources (manufacturing systems, maintenance systems, ...), Web sources (weather forecasts, energy prices, ...). You will also learn how to enable “intelligent control” between those systems, thereby building “System of Systems” applications.
Content: Hands-on examples and real systems will be studied, Systems of Systems architectures will be drafted for different application domains. Concepts such as Green Information Systems, Closed-Loop Lifecycle Management, Total Cost of Ownership and Fleet Management are key concepts for the achievable benefits from Systems of Systems. The main scope of the course is on architecting Information System Architectures for “Big Systems; however, business aspects, as well as societal and environmental aspects of such systems will be considered.
Assessment Methods and Criteria: Project work, examination
Substitutes for Courses: Replaces the former course CSE-E4675 Systems of Systems
Grading Scale: 0-5
Registration for Courses: Registration via WebOodi. Please see WebOodi for registration dates.

CS-E5370 Law in Digital Society (5-6 cr)

Responsible teacher: Nomi Byström; Martti Mäntylä
Level of the Course: Master's level
Teaching period: IV (Spring)
Workload: 30+0 (4+0)
Content: The topics of this course include a wide range of legal issues in the network society: regulation of the Internet of Things and Industrial Internet, data protection, software engineering: IT-contracts, copyright and other intellectual property rights, computer crimes and cyber security, etc.
Assessment Methods and Criteria: Examination and exercises.
Study Material: To be announced later.
Substitutes for Courses: Replaces former courses CSE-E4680 Law in Digital Society, T-76.5632 Legal Issues in Computing and T-76.5753 Law in Network Society.
Prerequisites: None
Evaluation: 0-5
Language of Instruction: English

CS-E5370 Law in Digital Society (5-6 sp)

Ansvarig lärare: Nomi Byström; Martti Mäntylä
Kursnivå: Master's level
Undervisningsperiod: IV (Spring)
Arbetsmängd: 30+0 (4+0)
Innehåll: The topics of this course include a wide range of legal issues in the network society: regulation of the Internet of Things and Industrial Internet, data protection, software engineering: IT-contracts, copyright and other intellectual property rights, computer crimes and cyber security, etc.
Metoder, arbetssätt och bedömningsgrunder: Examination and exercises.
Studiematerial: To be announced later.
Ersättande prestationer: Replaces former courses CSE-E4680 Law in Digital Society, T-76.5632 Legal Issues in Computing and T-76.5753 Law in Network Society.
Förkunskaper: None
Bedömningsskala: 0-5
Undervisningsspråk: English

CS-E5370 Law in Digital Society (5-6 cr)

Responsible teacher: Nomi Byström; Martti Mäntylä
Level of the Course: Master's level
Teaching Period: IV (Spring)
Workload: 30+0 (4+0)
Content: The topics of this course include a wide range of legal issues in the network society: regulation of the Internet of Things and Industrial Internet, data protection, software engineering: IT-contracts, copyright and other intellectual property rights, computer crimes and cyber security, etc.
Assessment Methods and Criteria: Examination and exercises.
Study Material: To be announced later.

Substitutes for Courses: Replaces former courses CSE-E4680 Law in Digital Society, T-76.5632 Legal Issues in Computing and T-76.5753 Law in Network Society.
Prerequisites: None
Grading Scale: 0-5
Language of Instruction: English

CS-E5380 Special Assignment on Enterprise Information Systems(V) (3-10 cr)

Responsible teacher: Martti Mäntylä; Kari Hiekkanen
Status of the Course: Optional course of the Enterprise Systems track in the Software and Service Engineering major.
Level of the Course: Master's level
Teaching period: (To be agreed with the teacher-in-charge.)
Workload: Varies based on the assignment.
Learning Outcomes: Become familiar with relevant literature in the agreed topic. Practice writing of scientific reports and articles.
Content: Independent essay on a chosen subject from the field of enterprise systems.
Assessment Methods and Criteria: Written essay.
Study Material: Agreed separately.
Substitutes for Courses: Replaces former courses CSE-E5655 / T-86.5150 Special Assignment on Enterprise Information Systems.
Evaluation: 0-5
Language of Instruction: Finnish and English.
Further Information: The contents of this course vary.

CS-E5380 Special Assignment on Enterprise Information Systems(V) (3-10 sp)

Ansvarig lärare: Martti Mäntylä; Kari Hiekkanen
Kursens status: Optional course of the Enterprise Systems track in the Software and Service Engineering major.
Kursnivå: Master's level
Undervisningsperiod: (To be agreed with the teacher-in-charge.)
Arbetsmängd: Varies based on the assignment.
Lärandemål: Become familiar with relevant literature in the agreed topic. Practice writing of scientific reports and articles.
Innehåll: Independent essay on a chosen subject from the field of enterprise systems.
Metoder, arbetssätt och bedömningsgrunder: Written essay.
Studiematerial: Agreed separately.
Ersättande prestationer: Replaces former courses CSE-E5655 / T-86.5150 Special Assignment on Enterprise Information Systems.
Bedömningsskala: 0-5
Undervisningsspråk: Finnish and English.
Tilläggsinformation: The contents of this course vary.

CS-E5380 Special Assignment on Enterprise Information Systems(V) (3-10 cr)

Responsible teacher: Martti Mäntylä; Kari Hiekkanen
Status of the Course: Optional course of the Enterprise Systems track in the Software and Service Engineering major.
Level of the Course: Master's level
Teaching Period: (To be agreed with the teacher-in-charge.)
Workload: Varies based on the assignment.
Learning Outcomes: Become familiar with relevant literature in the agreed topic. Practice writing of scientific reports and articles.
Content: Independent essay on a chosen subject from the field of enterprise systems.
Assessment Methods and Criteria: Written essay.
Study Material: Agreed separately.
Substitutes for Courses: Replaces former courses CSE-E5655 / T-86.5150 Special Assignment on Enterprise Information Systems.
Grading Scale: 0-5
Language of Instruction: Finnish and English.
Further Information: The contents of this course vary.

CS-E5390 Seminar on Law and Technology(V) (3-6 cr)

Responsible teacher: Martti Mäntylä; Timo Nyberg
Level of the Course: Master's level
Teaching period: IV-V (Spring)
Learning Outcomes: After the course the participants are able to understand the definitions and concepts of intellectual property rights, the contracts related to IPR, and strategies for IPR. Content: Forms of IPR (patents, trademarks, copyrights, database rights etc) and when to use them. How IPRs are used for business strategy e.g. for financing rounds. Role of contracts and in IPR generation & exploitation & licensing. Sources of IPR. Success stories from industry.
Assessment Methods and Criteria: Assessment will be based on a course assignment and/or an exam (optional).
Study Material: Schox 2011, Not So Obvious: An Introduction to Patent Law and Strategy. Other material will be announced later.
Substitutes for Courses: Replaces former course CSE-E5680 / T-76.5750 Seminar on Law and Technology.
Evaluation: 0-5
Language of Instruction: English
Further Information: The Seminar on Law and Technology focuses on Exploitation of Intellectual Property Rights (IPR). It is a practical hands-on course on IPR and strategy. The seminar is part of the Aalto Ventures Program offering. The course is open to all Aalto students and EIT ICT Labs master and doctoral school students. The contents of the course vary.

CS-E5390 Seminar on Law and Technology(V) (3-6 sp)

Ansvarig lärare: Martti Mäntylä; Timo Nyberg
Kursnivå: Master's level
Undervisningsperiod: IV-V (Spring)
Lärandemål: After the course the participants are able to understand the definitions and concepts of intellectual property rights, the contracts related to IPR, and strategies for IPR. Content: Forms of IPR (patents, trademarks, copyrights, database rights etc) and when to use them. How IPRs are used for business strategy e.g. for financing rounds. Role of contracts and in IPR generation & exploitation & licensing. Sources of IPR. Success stories from industry.
Metoder, arbetssätt och bedömningsgrunder: Assessment will be based on a course assignment and/or an exam (optional).
Studiematerial: Schox 2011, Not So Obvious: An Introduction to Patent Law and Strategy. Other material will be announced later.
Ersättande prestationer: Replaces former course CSE-E5680 / T-76.5750 Seminar on Law and Technology.
Bedömningsskala: 0-5
Undervisningsspråk: English
Tilläggsinformation: The Seminar on Law and Technology focuses on Exploitation of Intellectual Property Rights (IPR). It is a practical hands-on course on IPR and strategy. The seminar is part of the Aalto Ventures Program offering. The course is open to all Aalto students and EIT ICT Labs master and doctoral school students. The contents of the course vary.

CS-E5390 Seminar on Law and Technology(V) (3-6 cr)

Responsible teacher: Martti Mäntylä; Timo Nyberg
Level of the Course: Master's level
Teaching Period: IV-V (Spring)
Learning Outcomes: After the course the participants are able to understand the definitions and concepts of intellectual property rights, the contracts related to IPR, and strategies for IPR. Content: Forms of IPR (patents, trademarks, copyrights, database rights etc) and when to use them. How IPRs are used for business strategy e.g. for financing rounds. Role of contracts and in IPR generation & exploitation & licensing. Sources of IPR. Success stories from industry.
Assessment Methods and Criteria: Assessment will be based on a course assignment and/or an exam (optional).
Study Material: Schox 2011, Not So Obvious: An Introduction to Patent Law and Strategy. Other material will be announced later.
Substitutes for Courses: Replaces former course CSE-E5680 / T-76.5750 Seminar on Law and Technology.
Grading Scale: 0-5
Language of Instruction: English
Further Information: The Seminar on Law and Technology focuses on Exploitation of Intellectual Property Rights (IPR). It is a practical hands-on course

on IPR and strategy. The seminar is part of the Aalto Ventures Program offering. The course is open to all Aalto students and EIT ICT Labs master and doctoral school students. The contents of the course vary.

CS-E5400 Tietojärjestelmien hankinta ja hankejohtaminen (4-6 op)

Vastuuopettaja: Martti Mäntylä; Kari Hiekkanen
Opetusperiodi: IV
Osaamistavoitteet: Ymmärtää perusteet tietojärjestelmien hankinnasta ja hankejohtamisesta asiakkaan tai toimittajan roolissa.
Sisältö: Organisaation keskeiset tietojärjestelmät ja niiden elinkaari. Liiketoiminnan ja käyttäjien vaatimukset tietojärjestelmille. Vaatimusmäärittely, käytettävyys ja arkkitehtuurinäkökulmat hankinnassa ja tarjousten valmistelussa. Eri toimintamallit: valmisohjelmistot, ohjelmistoprojektit, pilvipalvelut, ulkoistus. Eri osapuolet ja niiden roolit. Hankintoihin liittyvä juridiikka.
Toteutus, työmuodot ja arvosteluperusteet: Ilmoitetaan myöhemmin
Oppimateriaali: Ilmoitetaan myöhemmin
Korvaavuudet: T-86.2010 Tietojärjestelmien hankinta ja hankejohtaminen
Arvosteluasteikko: 0-5
Opetuskieli: Suomi
Lisätietoja: The number of participants will be limited (100). Registrations will be prioritized in the following order: 1) the students of CCIS / SSE major; 2) students that have the course as a mandatory or elective part of their major or minor; 3) all other students based on registration order.

CS-E5400 Anskaffande av och portföljhantering för datasystem (4-6 sp)

Ansvarig lärare: Martti Mäntylä; Kari Hiekkanen
Undervisningsperiod: IV
Lärandemål: Att förstå kontext och frågeställningar relaterade till anskaffning och portföljhantering av datasystem ur både köpares och leverantörs synviklar.
Innehåll: Organisationens centrala datasystem och deras livscykel. Affärsverksamhetens och användarnas krav på datasystem. Kravspecifikation ur anskaffnings- och offertpreparationssynvinkel. Färdigprogram, skräddarsydda lösningar, mjukvara som service (SaaS). Outsourcing. Juridiska aspekter relaterade till anskaffningsprocessen.
Metoder, arbetssätt och bedömningsgrunder: Meddelas senare
Studiematerial: Meddelas senare
Ersättande prestationer: T-86.2010 Anskaffande av och portföljhantering för datasystem
Bedömningsskala: 0-5
Undervisningsspråk: Finska
Tilläggsinformation: The number of participants will be limited (100). Registrations will be prioritized in the following order: 1) the students of CCIS / SSE major; 2) students that have the course as a mandatory or elective part of their major or minor; 3) all other students based on registration order.

CS-E5400 IS Procurement and Portfolio management (4-6 cr)

Responsible teacher: Martti Mäntylä; Kari Hiekkanen
Teaching Period: IV
Learning Outcomes: You understand basic issues relating to Information System procurement and portfolio management in an Enterprise context.
Content: Core Enterprise IS and their lifecycle. Business expectations and user requirements. Tender and procurement processes. Issues related to off-the-shelf software, customized solutions, software services and outsourcing. Legal issues related to procurement processes. Role of various stakeholders (users, developers, business owners, vendors, integrators).
Assessment Methods and Criteria: Agreed separately
Study Material: Agreed separately
Substitutes for Courses: T-86.2010 IS Procurement and Portfolio management
Grading Scale: 0-5
Language of Instruction: Finnish
Further Information: The number of participants will be limited (100). Registrations will be prioritized in the following order: 1) the students of CCIS / SSE major; 2) students that have the course as a mandatory or elective part of their major or minor; 3) all other students based on registration order.

CS-E5410 Technology Entrepreneurship Seminar(V) (4 cr)

Responsible teacher: Olli Mutanen
Status of the Course: This course is part of the Aalto Ventures Program.
Level of the Course: Master's level
Teaching period: Organised when needed, I-V.
Workload: This is a 4 ECTS course (1cr ≅ 27 h work hours).
Learning Outcomes: The course aims to provide concrete and pragmatic approach to conducting entrepreneurship in a high technology product or a service based business.
Content: This course is for students who are interested in technology entrepreneurship. The course is arranged as a seminar series, with sessions held by experienced entrepreneurs or domain experts which present real-life case studies of technology based ventures. In the seminar students will become familiar with the practical tools and methods of planning and testing a business concept in the real world. To test a business concept, students will learn how to describe a business model, develop pitches and validate the businesses' key assumptions with easy (but fun!) online and offline experiments. Focus will be placed in understanding today's practical methods and tools for business concept analysis and validation.
Assessment Methods and Criteria: Grading scheme is as follows: 80% course exercise, 20% personal activity and team work capabilities.
Study Material: Lecture materials, selected journal and practitioner articles and complementary materials. Materials vary from year to year, and are announced during the course.
Substitutes for Courses: CSE-E5753 Technology Entrepreneurship Seminar and T-128.5400 Software Entrepreneurship Seminar.
Prerequisites: CS-E5100 / CSE-E4751 Introduction to IT Business and

Venturing and CSE-E4755 Management of a Technology Venture or similar knowledge
Evaluation: 0-5
Registration for Courses: Registration via WebOodi.
Language of Instruction: English
Further Information: The number of participants will be limited. Registrations will be prioritized in the following order: The students that have the course as a mandatory part of their study program will be prioritized first. The students that are participating in the Aalto Ventures Program or EIT I&E minor will be prioritized second. After this, all students are prioritized based on registration order.

CS-E5410 Technology Entrepreneurship Seminar(V) (4 sp)

Ansvarig lärare: Olli Mutanen
Kursens status: This course is part of the Aalto Ventures Program.
Kursnivå: Master's level
Undervisningsperiod: Organised when needed, I-V.
Arbetsmängd: This is a 4 ECTS course (1cr ≅ 27 h work hours).
Lärandemål: The course aims to provide concrete and pragmatic approach to conducting entrepreneurship in a high technology product or a service based business.
Innehåll: This course is for students who are interested in technology entrepreneurship. The course is arranged as a seminar series, with sessions held by experienced entrepreneurs or domain experts which present real-life case studies of technology based ventures. In the seminar students will become familiar with the practical tools and methods of planning and testing a business concept in the real world. To test a business concept, students will learn how to describe a business model, develop pitches and validate the businesses' key assumptions with easy (but fun!) online and offline experiments. Focus will be placed in understanding today's practical methods and tools for business concept analysis and validation.
Metoder, arbetssätt och bedömningsgrunder: Grading scheme is as follows: 80% course exercise, 20% personal activity and team work capabilities.
Studiematerial: Lecture materials, selected journal and practitioner articles and complementary materials. Materials vary from year to year, and are announced during the course.
Ersättande prestationer: CSE-E5753 Technology Entrepreneurship Seminar and T-128.5400 Software Entrepreneurship Seminar.
Förkunskaper: CS-E5100 / CSE-E4751 Introduction to IT Business and Venturing and CSE-E4755 Management of a Technology Venture or similar knowledge
Bedömningsskala: 0-5
Anmälning: Registration via WebOodi.
Undervisningsspråk: English
Tilläggsinformation: The number of participants will be limited. Registrations will be prioritized in the following order: The students that have the course as a

mandatory part of their study program will be prioritized first. The students that are participating in the Aalto Ventures Program or EIT I&E minor will be prioritized second. After this, all students are prioritized based on registration order.

CS-E5410 Technology Entrepreneurship Seminar(V) (4 cr)

Responsible teacher: Olli Mutanen
Status of the Course: This course is part of the Aalto Ventures Program.
Level of the Course: Master's level
Teaching Period: Organised when needed, I-V.
Workload: This is a 4 ECTS course (1cr ≅ 27 h work hours).
Learning Outcomes: The course aims to provide concrete and pragmatic approach to conducting entrepreneurship in a high technology product or a service based business.
Content: This course is for students who are interested in technology entrepreneurship. The course is arranged as a seminar series, with sessions held by experienced entrepreneurs or domain experts which present real-life case studies of technology based ventures. In the seminar students will become familiar with the practical tools and methods of planning and testing a business concept in the real world. To test a business concept, students will learn how to describe a business model, develop pitches and validate the businesses' key assumptions with easy (but fun!) online and offline experiments. Focus will be placed in understanding today's practical methods and tools for business concept analysis and validation.
Assessment Methods and Criteria: Grading scheme is as follows: 80% course exercise, 20% personal activity and team work capabilities.
Study Material: Lecture materials, selected journal and practitioner articles and complementary materials. Materials vary from year to year, and are announced during the course.
Substitutes for Courses: CSE-E5753 Technology Entrepreneurship Seminar and T-128.5400 Software Entrepreneurship Seminar.
Prerequisites: CS-E5100 / CSE-E4751 Introduction to IT Business and Venturing and CSE-E4755 Management of a Technology Venture or similar knowledge
Grading Scale: 0-5
Registration for Courses: Registration via WebOodi.
Language of Instruction: English
Further Information: The number of participants will be limited. Registrations will be prioritized in the following order: The students that have the course as a mandatory part of their study program will be prioritized first. The students that are participating in the Aalto Ventures Program or EIT I&E minor will be prioritized second. After this, all students are prioritized based on registration order.

CS-E5420 ICT Innovation I&E Thesis(V) (6 cr)

Responsible teacher: Olli Mutanen
Teaching period: This I&E Study course is part of the EIT Digital I&E Minor.is offered in periods I and II for the 2nd year EIT students.
Learning Outcomes: Students get the ability to apply, synthesize, and evaluate their prior I&E learning and acquire new knowledge and skills within a real business case by (1) identifying and assessing the impact of a technology in certain industry, market and/or organization, and (2) by analyzing the market and business environment and developing dimensions of the business model in relation with the business case..
After completion of the course, students have developed their abilities:
- to translate innovations into feasible business solutions (Entrepreneurship skills and competencies)
- to apply, synthesize, and evaluate prior I&E learning within a specific innovation or entrepreneurial project setting and a specific innovation area.
- to conduct a business analysis, make decisions and formulate recommendations or justify actions in a real environment.
- to choose and apply relevant concepts/methods and/or tools and collect relevant data for conducting a business analysis and making decisions in a real environment.
- to produce a professional writing on a business analysis topic.
- to apply concepts, methods and tools pertaining to identifying and assessing the impact/value of a technology in an industry, market and/or organization and the innovation / business opportunities it creates.
- in decision-making and leadership, based on a holistic understanding of the contributions of Higher Education, research and business to value creation, in limited sized teams and contexts (Leadership skills and competencies)

Content: The course is based on a group assignment to address an innovation or entrepreneurial case grounded in real life. A large autonomy is given to the students to organize and achieve their goals. Students will work in teams of around 4-5 students, but each student will also have an individual responsibility of certain part of the study project. Students' assignments to cases will be based on students' interest, and the innovation or entrepreneurial project may be originating also from:
- Cases issued from EIT Digital Innovation Action Lines: within Activities, Partners / Business Community projects,
- Cases based on the continuation of students Summer School (or BDLab) project,
- Cases within other innovation or entrepreneurial projects rooted in a real-life environment.

The team will identify and address two (2) challenges/questions in the context of their case:
- One fixed and common topic that will be related to identifying and assessing the impact/value of a technology in an industry, market and/or organization, in the context of the innovation or entrepreneurial case,
- One case-dependent topic that will be related to analyzing the market / business environment, developing aspects of the business model in relation with

the innovation or entrepreneurial case.
For each challenge/question, the students will cover four (4) generic steps of an explorative business analysis:
1. Identification of the relevant challenge/question,
2. Acquisition of applicable concepts/methods/tools,
3. Observations (data collection) on a selected part of the case,
4. Analysis and interpretation.

Assessment Methods and Criteria: The assessment is based on a written group report, and may include also a presentation of the project results to the class and teaching personnel, and/or an oral defense, and/or a share of peer-to-peer assessment. Specific assessment criteria will be presented at the beginning of the course.
The grade for each student includes a share of individual assessment. 50% of the grade is based on 'business analysis competence' grading criteria' and 50% on 'general I&E competence' grading criteria.
Substitutes for Courses: T-106.5330 ICT Innovation I&E Thesis
Prerequisites: According to general prerequisites for EIT Digital Master School programs; attendance to the I&E Basics, BDLab and EIT Digital Summer School modules.
Evaluation: 0-5
Language of Instruction: English

CS-E5420 ICT Innovation I&E Thesis(V) (6 sp)

Ansvarig lärare: Olli Mutanen
Undervisningsperiod: This I&E Study course is part of the EIT Digital I&E Minor.is offered in periods I and II for the 2nd year EIT students.
Lärandemål: Students get the ability to apply, synthesize, and evaluate their prior I&E learning and acquire new knowledge and skills within a real business case by (1) identifying and assessing the impact of a technology in certain industry, market and/or organization, and (2) by analyzing the market and business environment and developing dimensions of the business model in relation with the business case..
After completion of the course, students have developed their abilities:
- to translate innovations into feasible business solutions (Entrepreneurship skills and competencies)
- to apply, synthesize, and evaluate prior I&E learning within a specific innovation or entrepreneurial project setting and a specific innovation area.
- to conduct a business analysis, make decisions and formulate recommendations or justify actions in a real environment.
- to choose and apply relevant concepts/methods and/or tools and collect relevant data for conducting a business analysis and making decisions in a real environment.
- to produce a professional writing on a business analysis topic.
- to apply concepts, methods and tools pertaining to identifying and assessing the impact/value of a technology in an industry, market and/or organization and the innovation / business opportunities it creates.

• in decision-making and leadership, based on a holistic understanding of the contributions of Higher Education, research and business to value creation, in limited sized teams and contexts (Leadership skills and competencies)

Innehåll: The course is based on a group assignment to address an innovation or entrepreneurial case grounded in real life. A large autonomy is given to the students to organize and achieve their goals. Students will work in teams of around 4-5 students, but each student will also have an individual responsibility of certain part of the study project. Students' assignments to cases will be based on students' interest, and the innovation or entrepreneurial project may be originating also from:

• Cases issued from EIT Digital Innovation Action Lines: within Activities, Partners / Business Community projects,
• Cases based on the continuation of students Summer School (or BDLab) project,
• Cases within other innovation or entrepreneurial projects rooted in a real-life environment.

The team will identify and address two (2) challenges/questions in the context of their case:

• One fixed and common topic that will be related to identifying and assessing the impact/value of a technology in an industry, market and/or organization, in the context of the innovation or entrepreneurial case,
• One case-dependent topic that will be related to analyzing the market / business environment, developing aspects of the business model in relation with the innovation or entrepreneurial case.

For each challenge/question, the students will cover four (4) generic steps of an explorative business analysis:

1. Identification of the relevant challenge/question,
2. Acquisition of applicable concepts/methods/tools,
3. Observations (data collection) on a selected part of the case,
4. Analysis and interpretation.

Metoder, arbetssätt och bedömningsgrunder: The assessment is based on a written group report, and may include also a presentation of the project results to the class and teaching personnel, and/or an oral defense, and/or a share of peer-to-peer assessment. Specific assessment criteria will be presented at the beginning of the course.

The grade for each student includes a share of individual assessment. 50% of the grade is based on 'business analysis competence' grading criteria' and 50% on 'general I&E competence' grading criteria.

Ersättande prestationer: T-106.5330 ICT Innovation I&E Thesis

Förkunskaper: According to general prerequisites for EIT Digital Master School programs; attendance to the I&E Basics, BDLab and EIT Digital Summer School modules.

Bedömningsskala: 0-5

Undervisningsspråk: English

CS-E5420 ICT Innovation I&E Thesis(V) (6 cr)

Responsible teacher: Olli Mutanen
Teaching Period: This I&E Study course is part of the EIT Digital I&E Minor.is offered in periods I and II for the 2nd year EIT students.
Learning Outcomes: Students get the ability to apply, synthesize, and evaluate their prior I&E learning and acquire new knowledge and skills within a real business case by (1) identifying and assessing the impact of a technology in certain industry, market and/or organization, and (2) by analyzing the market and business environment and developing dimensions of the business model in relation with the business case..
After completion of the course, students have developed their abilities:
- to translate innovations into feasible business solutions (Entrepreneurship skills and competencies)
- to apply, synthesize, and evaluate prior I&E learning within a specific innovation or entrepreneurial project setting and a specific innovation area.
- to conduct a business analysis, make decisions and formulate recommendations or justify actions in a real environment.
- to choose and apply relevant concepts/methods and/or tools and collect relevant data for conducting a business analysis and making decisions in a real environment.
- to produce a professional writing on a business analysis topic.
- to apply concepts, methods and tools pertaining to identifying and assessing the impact/value of a technology in an industry, market and/or organization and the innovation / business opportunities it creates.
- in decision-making and leadership, based on a holistic understanding of the contributions of Higher Education, research and business to value creation, in limited sized teams and contexts (Leadership skills and competencies)

Content: The course is based on a group assignment to address an innovation or entrepreneurial case grounded in real life. A large autonomy is given to the students to organize and achieve their goals. Students will work in teams of around 4-5 students, but each student will also have an individual responsibility of certain part of the study project. Students' assignments to cases will be based on students' interest, and the innovation or entrepreneurial project may be originating also from:
- Cases issued from EIT Digital Innovation Action Lines: within Activities, Partners / Business Community projects,
- Cases based on the continuation of students Summer School (or BDLab) project,
- Cases within other innovation or entrepreneurial projects rooted in a real-life environment.

The team will identify and address two (2) challenges/questions in the context of their case:
- One fixed and common topic that will be related to identifying and assessing the impact/value of a technology in an industry, market and/or organization, in the context of the innovation or entrepreneurial case,
- One case-dependent topic that will be related to analyzing the market / business environment, developing aspects of the business model in relation with

the innovation or entrepreneurial case.
For each challenge/question, the students will cover four (4) generic steps of an explorative business analysis:
1. Identification of the relevant challenge/question,
2. Acquisition of applicable concepts/methods/tools,
3. Observations (data collection) on a selected part of the case,
4. Analysis and interpretation.

Assessment Methods and Criteria: The assessment is based on a written group report, and may include also a presentation of the project results to the class and teaching personnel, and/or an oral defense, and/or a share of peer-to-peer assessment. Specific assessment criteria will be presented at the beginning of the course.
The grade for each student includes a share of individual assessment. 50% of the grade is based on 'business analysis competence' grading criteria' and 50% on 'general I&E competence' grading criteria.
Substitutes for Courses: T-106.5330 ICT Innovation I&E Thesis
Prerequisites: According to general prerequisites for EIT Digital Master School programs; attendance to the I&E Basics, BDLab and EIT Digital Summer School modules.
Grading Scale: 0-5
Language of Instruction: English

CS-E5430 ICT Innovation Summer School(V) (3-9 cr)

Responsible teacher: Olli Mutanen
Teaching period: Summer
Learning Outcomes: Understanding the process of Business Model Generation, and knowing how to define and analyse the nine building blocks (customer segments, customer relations, channels, value proposition, key activities, key resources, key partners, cost structure and revenue streams). The ability to perform a business development process in the context of a societally relevant thematic area (for example, Health and Wellbeing, Smart Energy Systems) and understanding how technology and innovation interact with all stakeholders (competitors, alliances, networks, markets, etc.) Understanding usability, business life-cycles, market segments, global/market trends, and recognizing their relative importance for product and service development The ability to transform new innovations into viable business solutions on the commercial market, combined with decision-making and leadership competences The ability to reflect upon ethical, societal, scientific and sustainability considerations when developing new products, technologies and business models.
Content: Ideation, identifying thematic innovations and opportunities, concept development, integrating with stakeholders, usability, business life-cycles, operations and maintenance.
Assessment Methods and Criteria: The course is implemented during summer as a two-week intensive course, possibly consisting of two parts. It contains lectures (10-20%), guided group work (40%), individual work (20-30%) and company visits or field work with users (20-30%).

Grading is based on group presentation where the results are evaluated by a panel of experts.
Study Material: A. Osterwalder & Y. Pigneur (2010). Business Model Generation, John Wiley & Sons.
Substitutes for Courses: T-106.5320 ICT Innovation Summer School
Evaluation: 0-5. May be graded as pass/fail
Language of Instruction: English

CS-E5430 ICT Innovation Summer School(V) (3-9 sp)

Ansvarig lärare: Olli Mutanen
Undervisningsperiod: Summer
Lärandemål: Understanding the process of Business Model Generation, and knowing how to define and analyse the nine building blocks (customer segments, customer relations, channels, value proposition, key activities, key resources, key partners, cost structure and revenue streams). The ability to perform a business development process in the context of a societally relevant thematic area (for example, Health and Wellbeing, Smart Energy Systems) and understanding how technology and innovation interact with all stakeholders (competitors, alliances, networks, markets, etc.) Understanding usability, business life-cycles, market segments, global/market trends, and recognizing their relative importance for product and service development The ability to transform new innovations into viable business solutions on the commercial market, combined with decision-making and leadership competences The ability to reflect upon ethical, societal, scientific and sustainability considerations when developing new products, technologies and business models.
Innehåll: Ideation, identifying thematic innovations and opportunities, concept development, integrating with stakeholders, usability, business life-cycles, operations and maintenance.
Metoder, arbetssätt och bedömningsgrunder: The course is implemented during summer as a two-week intensive course, possibly consisting of two parts. It contains lectures (10-20%), guided group work (40%), individual work (20-30%) and company visits or field work with users (20-30%).
Grading is based on group presentation where the results are evaluated by a panel of experts.
Studiematerial: A. Osterwalder & Y. Pigneur (2010). Business Model Generation, John Wiley & Sons.
Ersättande prestationer: T-106.5320 ICT Innovation Summer School
Bedömningsskala: 0-5. May be graded as pass/fail
Undervisningsspråk: English

CS-E5430 ICT Innovation Summer School(V) (3-9 cr)

Responsible teacher: Olli Mutanen
Teaching Period: Summer
Learning Outcomes: Understanding the process of Business Model Generation, and knowing how to define and analyse the nine building blocks (customer segments, customer relations, channels, value proposition, key activities, key

resources, key partners, cost structure and revenue streams). The ability to perform a business development process in the context of a societally relevant thematic area (for example, Health and Wellbeing, Smart Energy Systems) and understanding how technology and innovation interact with all stakeholders (competitors, alliances, networks, markets, etc.) Understanding usability, business life-cycles, market segments, global/market trends, and recognizing their relative importance for product and service development The ability to transform new innovations into viable business solutions on the commercial market, combined with decision-making and leadership competences The ability to reflect upon ethical, societal, scientific and sustainability considerations when developing new products, technologies and business models.
Content: Ideation, identifying thematic innovations and opportunities, concept development, integrating with stakeholders, usability, business life-cycles, operations and maintenance.
Assessment Methods and Criteria: The course is implemented during summer as a two-week intensive course, possibly consisting of two parts. It contains lectures (10-20%), guided group work (40%), individual work (20-30%) and company visits or field work with users (20-30%).
Grading is based on group presentation where the results are evaluated by a panel of experts.
Study Material: A. Osterwalder & Y. Pigneur (2010). Business Model Generation, John Wiley & Sons.
Substitutes for Courses: T-106.5320 ICT Innovation Summer School
Grading Scale: 0-5. May be graded as pass/fail
Language of Instruction: English

CS-E5440 Growth and Internationalization of Technology SMEs (4 cr)

Responsible teacher: Olli Mutanen
Status of the Course: This course is part of the Aalto Ventures Program and Master's Programme in ICT Innovation studies belonging to the 30 ECTS minor on Innovation and Entrepreneurship (I&E) in ICT.
Level of the Course: Master's level
Teaching period: V (Spring)
Workload: This is a 4 ECTS course. The expected student work hours required are as follows: Seminars and lectures: 24h, Group assignments and individual work: 84h. Group assignments are based on real venture cases and students are expected to work in teams.
Learning Outcomes: Students will familiarize themselves with how to do a market analysis for an internationalizing technology (service) venture, how to analyze and adjust the venture's offering according to the market environment and how to make a go-to-market plan.
Content: Theory base for firm level growth and internationalization models. The course exercise done in teams involves creating analyses of markets and competitive environments, optimizing product (service) offerings, and developing a go-to-market plan. Each team present results of the course exercise to the class as well as company representatives in person. In addition, each group gives

feedback to other teams in the form of peer evaluations.
Assessment Methods and Criteria: Group assessment based on the three assignments 60%, group assessment based on feedback from other groups 20%, and personal assessment based on activity 20%.
Study Material: Lecture materials, selected journal and practitioner articles and complementary materials. Materials vary from year to year, and are announced during the lectures.
Substitutes for Courses: Replaces the former courses T-128.6790 Special Course in Software Business and CSE-E5754 / T-128.6000 Growth and Internationalization of Software SMEs.
Prerequisites: CS-E5100 / CSE-E4751 Introduction to IT Business and Venturing and CSE-E4755 Management of a Technology Venture / T-128.2500 Management of a Software Venture or similar knowledge.
Evaluation: 0-5
Registration for Courses: Enrollment in WebOodi.
Language of Instruction: English
Further Information: This course is intended for students who have studied management or marketing, and are interested in working in sales, marketing, product management, or general management roles in technology and/or service based ventures. The course is best suited for late Master's level studies. The number of participants will be limited.
Registrations will be prioritized in the following order: The students that have the course as a mandatory part of their study program will be prioritized first. The students that are participating in the Aalto Ventures Program or EIT I&E minor will be prioritized second. After this, all students are prioritized based on registration order.

CS-E5440 Growth and Internationalization of Technology SMEs (4 sp)

Ansvarig lärare: Olli Mutanen
Kursens status: This course is part of the Aalto Ventures Program and Master's Programme in ICT Innovation studies belonging to the 30 ECTS minor on Innovation and Entrepreneurship (I&E) in ICT.
Kursnivå: Master's level
Undervisningsperiod: V (Spring)
Arbetsmängd: This is a 4 ECTS course. The expected student work hours required are as follows: Seminars and lectures: 24h, Group assignments and individual work: 84h. Group assignments are based on real venture cases and students are expected to work in teams.
Lärandemål: Students will familiarize themselves with how to do a market analysis for an internationalizing technology (service) venture, how to analyze and adjust the venture's offering according to the market environment and how to make a go-to-market plan.
Innehåll: Theory base for firm level growth and internationalization models. The course exercise done in teams involves creating analyses of markets and competitive environments, optimizing product (service) offerings, and developing a go-to-market plan. Each team present results of the course exercise to the class

as well as company representatives in person. In addition, each group gives feedback to other teams in the form of peer evaluations.
Metoder, arbetssätt och bedömningsgrunder: Group assessment based on the three assignments 60%, group assessment based on feedback from other groups 20%, and personal assessment based on activity 20%.
Studiematerial: Lecture materials, selected journal and practitioner articles and complementary materials. Materials vary from year to year, and are announced during the lectures.
Ersättande prestationer: Replaces the former courses T-128.6790 Special Course in Software Business and CSE-E5754 / T-128.6000 Growth and Internationalization of Software SMEs.
Förkunskaper: CS-E5100 / CSE-E4751 Introduction to IT Business and Venturing and CSE-E4755 Management of a Technology Venture / T-128.2500 Management of a Software Venture or similar knowledge.
Bedömningsskala: 0-5
Anmälning: Enrollment in WebOodi.
Undervisningsspråk: English
Tilläggsinformation: This course is intended for students who have studied management or marketing, and are interested in working in sales, marketing, product management, or general management roles in technology and/or service based ventures. The course is best suited for late Master's level studies. The number of participants will be limited.
Registrations will be prioritized in the following order: The students that have the course as a mandatory part of their study program will be prioritized first. The students that are participating in the Aalto Ventures Program or EIT I&E minor will be prioritized second. After this, all students are prioritized based on registration order.

CS-E5440 Growth and Internationalization of Technology SMEs (4 cr)

Responsible teacher: Olli Mutanen
Status of the Course: This course is part of the Aalto Ventures Program and Master's Programme in ICT Innovation studies belonging to the 30 ECTS minor on Innovation and Entrepreneurship (I&E) in ICT.
Level of the Course: Master's level
Teaching Period: V (Spring)
Workload: This is a 4 ECTS course. The expected student work hours required are as follows: Seminars and lectures: 24h, Group assignments and individual work: 84h. Group assignments are based on real venture cases and students are expected to work in teams.
Learning Outcomes: Students will familiarize themselves with how to do a market analysis for an internationalizing technology (service) venture, how to analyze and adjust the venture's offering according to the market environment and how to make a go-to-market plan.
Content: Theory base for firm level growth and internationalization models. The course exercise done in teams involves creating analyses of markets and competitive environments, optimizing product (service) offerings, and developing

a go-to-market plan. Each team present results of the course exercise to the class as well as company representatives in person. In addition, each group gives feedback to other teams in the form of peer evaluations.
Assessment Methods and Criteria: Group assessment based on the three assignments 60%, group assessment based on feedback from other groups 20%, and personal assessment based on activity 20%.
Study Material: Lecture materials, selected journal and practitioner articles and complementary materials. Materials vary from year to year, and are announced during the lectures.
Substitutes for Courses: Replaces the former courses T-128.6790 Special Course in Software Business and CSE-E5754 / T-128.6000 Growth and Internationalization of Software SMEs.
Prerequisites: CS-E5100 / CSE-E4751 Introduction to IT Business and Venturing and CSE-E4755 Management of a Technology Venture / T-128.2500 Management of a Software Venture or similar knowledge.
Grading Scale: 0-5
Registration for Courses: Enrollment in WebOodi.
Language of Instruction: English
Further Information: This course is intended for students who have studied management or marketing, and are interested in working in sales, marketing, product management, or general management roles in technology and/or service based ventures. The course is best suited for late Master's level studies. The number of participants will be limited.
Registrations will be prioritized in the following order: The students that have the course as a mandatory part of their study program will be prioritized first. The students that are participating in the Aalto Ventures Program or EIT I&E minor will be prioritized second. After this, all students are prioritized based on registration order.

CS-E5450 Multimedia Programming (4 cr)

Responsible teacher: Petri Vuorimaa
Level of the Course: Master's level
Teaching period: (I – II) Course not offered in 2016-17.
Workload: 28 + 0 (2 + 0)
Learning Outcomes: After the course you will know how to build interactive multimedia applications using HTML5, JavaScript and CSS. You learn to access online services, stream video and audio from online content sources, capture streams from on-board webcam and microphone, and to embed these in a webpage. You will also learn the principles on interactive 2D and 3D graphics using canvas, WebGL (three.js) and SVG APIs, how to synthesize and process audio, and how to add augmented maps into your application. You will learn how to work with multi-touch and mouse-based interaction, and finally, how to mash up these techniques together into an engaging multimedia application.
Content: The topic of the course is interactive multimedia application development using web technologies. Key concepts include multimedia and interaction related W3C standards and most important 3rd party APIs.

Assessment Methods and Criteria: The course is composed of lectures and hands-on programming sessions (participation 20%), student presentations (30%) and small case programming assignment (50%).
Study Material: Lecture slides and online material.
Substitutes for Courses: Replaces the former course T-111.5350 Multimedia Programming.
Prerequisites: ME-C2300 Basics of web publishing or equivalent knowledge (HTML5 + JavaScript).
Evaluation: 0-5
Language of Instruction: English

CS-E5450 Multimedia Programming (4 sp)

Ansvarig lärare: Petri Vuorimaa
Kursnivå: Master's level
Undervisningsperiod: (I – II) Course not offered in 2016-17.
Arbetsmängd: 28 + 0 (2 + 0)
Lärandemål: After the course you will know how to build interactive multimedia applications using HTML5, JavaScript and CSS. You learn to access online services, stream video and audio from online content sources, capture streams from on-board webcam and microphone, and to embed these in a webpage. You will also learn the principles on interactive 2D and 3D graphics using canvas, WebGL (three.js) and SVG APIs, how to synthesize and process audio, and how to add augmented maps into your application. You will learn how to work with multi-touch and mouse-based interaction, and finally, how to mash up these techniques together into an engaging multimedia application.
Innehåll: The topic of the course is interactive multimedia application development using web technologies. Key concepts include multimedia and interaction related W3C standards and most important 3rd party APIs.
Metoder, arbetssätt och bedömningsgrunder: The course is composed of lectures and hands-on programming sessions (participation 20%), student presentations (30%) and small case programming assignment (50%).
Studiematerial: Lecture slides and online material.
Ersättande prestationer: Replaces the former course T-111.5350 Multimedia Programming.
Förkunskaper: ME-C2300 Basics of web publishing or equivalent knowledge (HTML5 + JavaScript).
Bedömningsskala: 0-5
Undervisningsspråk: English

CS-E5450 Multimedia Programming (4 cr)

Responsible teacher: Petri Vuorimaa
Level of the Course: Master's level
Teaching Period: (I – II) Course not offered in 2016-17.
Workload: 28 + 0 (2 + 0)
Learning Outcomes: After the course you will know how to build interactive multimedia applications using HTML5, JavaScript and CSS. You learn to access

online services, stream video and audio from online content sources, capture streams from on-board webcam and microphone, and to embed these in a webpage. You will also learn the principles on interactive 2D and 3D graphics using canvas, WebGL (three.js) and SVG APIs, how to synthesize and process audio, and how to add augmented maps into your application. You will learn how to work with multi-touch and mouse-based interaction, and finally, how to mash up these techniques together into an engaging multimedia application.
Content: The topic of the course is interactive multimedia application development using web technologies. Key concepts include multimedia and interaction related W3C standards and most important 3rd party APIs.
Assessment Methods and Criteria: The course is composed of lectures and hands-on programming sessions (participation 20%), student presentations (30%) and small case programming assignment (50%).
Study Material: Lecture slides and online material.
Substitutes for Courses: Replaces the former course T-111.5350 Multimedia Programming.
Prerequisites: ME-C2300 Basics of web publishing or equivalent knowledge (HTML5 + JavaScript).
Grading Scale: 0-5
Language of Instruction: English

CS-E5500 Acoustical Measurements (5 cr)

Responsible teacher: Tapio Lokki
Status of the Course: Compulsory course of the CCIS Acoustics and Audio Technology major.
Level of the Course: Master's level
Teaching period: II (Autumn)
Workload: Lectures 24 h (4 h / week). Exercise 10 h (measurements). Own work 100 h (reading of material, analysis of special assignment measurements and writing of special assignment reports, writing the learning diaries). Total: 134 h.
Learning Outcomes: The student understands basic acoustical measurements and can perform measurements with standard techniques. The student is also familiar with more advanced techniques and is well aware of limitations and problems in measurements. Moreover, the student can interpret the results and understands the uncertainties of different measurement techniques.
Content: Acoustical measurement techniques in theory and in practice. The main emphasis is in measurements related to room and building acoustics, but also environmental noise measurements are covered. The use of standard measuring equipment is introduced also in theory and in practice. The course include a special assignments and some smaller measurement demonstrations.
Assessment Methods and Criteria: Learning diaries and assignments.
Study Material: Lecture notes, articles, and standards. All available via MyCourses.
Substitutes for Courses: Replaces the courses ME-E2430 Acoustical Measurements / S-89.3330 Exercise on Acoustical Measurements and S-89.3430 Akustinen mittaustekniikka L.

Prerequisites: ELEC-E5600 Communication Acoustics.
Evaluation: 0-5
Registration for Courses: WebOodi.
Language of Instruction: English

CS-E5500 Acoustical Measurements (5 sp)

Ansvarig lärare: Tapio Lokki
Kursens status: Compulsory course of the CCIS Acoustics and Audio Technology major.
Kursnivå: Master's level
Undervisningsperiod: II (Autumn)
Arbetsmängd: Lectures 24 h (4 h / week). Exercise 10 h (measurements). Own work 100 h (reading of material, analysis of special assignment measurements and writing of special assignment reports, writing the learning diaries). Total: 134 h.
Lärandemål: The student understands basic acoustical measurements and can perform measurements with standard techniques. The student is also familiar with more advanced techniques and is well aware of limitations and problems in measurements. Moreover, the student can interpret the results and understands the uncertainties of different measurement techniques.
Innehåll: Acoustical measurement techniques in theory and in practice. The main emphasis is in measurements related to room and building acoustics, but also environmental noise measurements are covered. The use of standard measuring equipment is introduced also in theory and in practice. The course include a special assignments and some smaller measurement demonstrations.
Metoder, arbetssätt och bedömningsgrunder: Learning diaries and assignments.
Studiematerial: Lecture notes, articles, and standards. All available via MyCourses.
Ersättande prestationer: Replaces the courses ME-E2430 Acoustical Measurements / S-89.3330 Exercise on Acoustical Measurements and S-89.3430 Akustinen mittaustekniikka L.
Förkunskaper: ELEC-E5600 Communication Acoustics.
Bedömningsskala: 0-5
Anmälning: WebOodi.
Undervisningsspråk: English

CS-E5500 Acoustical Measurements (5 cr)

Responsible teacher: Tapio Lokki
Status of the Course: Compulsory course of the CCIS Acoustics and Audio Technology major.
Level of the Course: Master's level
Teaching Period: II (Autumn)
Workload: Lectures 24 h (4 h / week). Exercise 10 h (measurements). Own work 100 h (reading of material, analysis of special assignment measurements and writing of special assignment reports, writing the learning diaries). Total: 134 h.
Learning Outcomes: The student understands basic acoustical measurements and

can perform measurements with standard techniques. The student is also familiar with more advanced techniques and is well aware of limitations and problems in measurements. Moreover, the student can interpret the results and understands the uncertainties of different measurement techniques.
Content: Acoustical measurement techniques in theory and in practice. The main emphasis is in measurements related to room and building acoustics, but also environmental noise measurements are covered. The use of standard measuring equipment is introduced also in theory and in practice. The course include a special assignments and some smaller measurement demonstrations.
Assessment Methods and Criteria: Learning diaries and assignments.
Study Material: Lecture notes, articles, and standards. All available via MyCourses.
Substitutes for Courses: Replaces the courses ME-E2430 Acoustical Measurements / S-89.3330 Exercise on Acoustical Measurements and S-89.3430 Akustinen mittaustekniikka L.
Prerequisites: ELEC-E5600 Communication Acoustics.
Grading Scale: 0-5
Registration for Courses: WebOodi.
Language of Instruction: English

CS-E5510 Room Acoustics (5 cr)

Responsible teacher: Tapio Lokki
Status of the Course: Compulsory course in CCIS Acoustics and Audio Technology major
Level of the Course: M.Sc. / postgraduate
Teaching period: III – IV (Spring 2017)
Workload: Lectures/demonstrations 28 h (4 h / week). Independent work 10 h (reading of material special assignment(s)).
Learning Outcomes: After the course the student masters basic knowledge of room acoustics theory and design, and knows the basics of room acoustics modeling.
Content: Basics of room acoustics, room acoustic modeling, acoustic conditions of halls and small rooms, room and room acoustical design.
Assessment Methods and Criteria: Examination and assignment(s).
Substitutes for Courses: Replaces the course ME-E2420 / S-89.3421 Room Acoustics.
Prerequisites: ELEC-E5600 Communication Acoustics, ELEC-E5610 Acoustics and Physics of Sound, ME-E2430 Acoustical Measurements or equal knowledge.
Evaluation: 0-5
Registration for Courses: WebOodi
Language of Instruction: English

CS-E5510 Room Acoustics (5 sp)

Ansvarig lärare: Tapio Lokki
Kursens status: Compulsory course in CCIS Acoustics and Audio Technology major

Kursnivå: M.Sc. / postgraduate
Undervisningsperiod: III – IV (Spring 2017)
Arbetsmängd: Lectures/demonstrations 28 h (4 h / week). Independent work 10 h (reading of material special assignment(s)).
Lärandemål: After the course the student masters basic knowledge of room acoustics theory and design, and knows the basics of room acoustics modeling.
Innehåll: Basics of room acoustics, room acoustic modeling, acoustic conditions of halls and small rooms, room and room acoustical design.
Metoder, arbetssätt och bedömningsgrunder: Examination and assignment(s).
Ersättande prestationer: Replaces the course ME-E2420 / S-89.3421 Room Acoustics.
Förkunskaper: ELEC-E5600 Communication Acoustics, ELEC-E5610 Acoustics and Physics of Sound, ME-E2430 Acoustical Measurements or equal knowledge.
Bedömningsskala: 0-5
Anmälning: WebOodi
Undervisningsspråk: English

CS-E5510 Room Acoustics (5 cr)

Responsible teacher: Tapio Lokki
Status of the Course: Compulsory course in CCIS Acoustics and Audio Technology major
Level of the Course: M.Sc. / postgraduate
Teaching Period: III – IV (Spring 2017)
Workload: Lectures/demonstrations 28 h (4 h / week). Independent work 10 h (reading of material special assignment(s)).
Learning Outcomes: After the course the student masters basic knowledge of room acoustics theory and design, and knows the basics of room acoustics modeling.
Content: Basics of room acoustics, room acoustic modeling, acoustic conditions of halls and small rooms, room and room acoustical design.
Assessment Methods and Criteria: Examination and assignment(s).
Substitutes for Courses: Replaces the course ME-E2420 / S-89.3421 Room Acoustics.
Prerequisites: ELEC-E5600 Communication Acoustics, ELEC-E5610 Acoustics and Physics of Sound, ME-E2430 Acoustical Measurements or equal knowledge.
Grading Scale: 0-5
Registration for Courses: WebOodi
Language of Instruction: English

CS-E5520 Advanced Computer Graphics(V) (5 cr)

Responsible teacher: Jaakko Lehtinen
Level of the Course: Master's level
Teaching period: III-V (Spring)
Workload: 16 + 20 (2 + 2).
Learning Outcomes: Contents vary by year. A solid understanding of a particular

subfield of computer graphics and its state of the art, and ability to put the understanding to practice through programming.
Content: Contents vary by year, but always a deeper dive into the theory, algorithms, and their practical implementation of a particular subfield of computer graphics. Example: the topic for spring 2013 was physically based rendering, both its theory and numerical methods for generating realistic pictures.
Assessment Methods and Criteria: Programming assignments (90%), participation (10%).
Study Material: Lecture slides, online material.
Substitutes for Courses: Replaces courses ME-E4100 Advanced Computer Graphics, T-111.5300/T-111.5310 Advanced Course in Computer Graphics and T-111.5450 Computer Animation.
Prerequisites: CS-C3100 / ME-C3100 Computer Graphics, C/C++ programming language.
Evaluation: 0 - 5
Language of Instruction: English

CS-E5520 Advanced Computer Graphics(V) (5 sp)

Ansvarig lärare: Jaakko Lehtinen
Kursnivå: Master's level
Undervisningsperiod: III-V (Spring)
Arbetsmängd: 16 + 20 (2 + 2).
Lärandemål: Contents vary by year. A solid understanding of a particular subfield of computer graphics and its state of the art, and ability to put the understanding to practice through programming.
Innehåll: Contents vary by year, but always a deeper dive into the theory, algorithms, and their practical implementation of a particular subfield of computer graphics. Example: the topic for spring 2013 was physically based rendering, both its theory and numerical methods for generating realistic pictures.
Metoder, arbetssätt och bedömningsgrunder: Programming assignments (90%), participation (10%).
Studiematerial: Lecture slides, online material.
Ersättande prestationer: Replaces courses ME-E4100 Advanced Computer Graphics, T-111.5300/T-111.5310 Advanced Course in Computer Graphics and T-111.5450 Computer Animation.
Förkunskaper: CS-C3100 / ME-C3100 Computer Graphics, C/C++ programming language.
Bedömningsskala: 0 - 5
Undervisningsspråk: English

CS-E5520 Advanced Computer Graphics(V) (5 cr)

Responsible teacher: Jaakko Lehtinen
Level of the Course: Master's level
Teaching Period: III-V (Spring)
Workload: 16 + 20 (2 + 2).
Learning Outcomes: Contents vary by year. A solid understanding of a particular

subfield of computer graphics and its state of the art, and ability to put the understanding to practice through programming.
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Assessment Methods and Criteria: Programming assignments (90%), participation (10%).
Study Material: Lecture slides, online material.
Substitutes for Courses: Replaces courses ME-E4100 Advanced Computer Graphics, T-111.5300/T-111.5310 Advanced Course in Computer Graphics and T-111.5450 Computer Animation.
Prerequisites: CS-C3100 / ME-C3100 Computer Graphics, C/C++ programming language.
Grading Scale: 0 - 5
Language of Instruction: English

CS-E5600 Aesthetics (3 cr)

Level of the Course: Master's level
Teaching period: III – V (Spring)
Workload: Lectures 9 h, workshops 30 h, independent work in groups.
Learning Outcomes: The student understands different conceptions of beauty, how they relate to historical periods, and theoretical assertions based on philosophical and artistic investigation of sensation.
Content: Introduction to basic concepts of aesthetics through realizations of garden design, the sensory ideal in the western world. The practicum of aesthetics texts covers the central concepts of aesthetics from mimesis to post-modern. As project work, students working in groups design "today's garden" reflecting their views and values.
Assessment Methods and Criteria: Lectures, practicums, group work, written exam and exercises. The written exam has to be passed before the final exercises. Half of the grade is based on the garden design and the other half is based on theoretical argumentation behind the design using concepts of aesthetics, art history and philosophy in a coherent way.
Substitutes for Courses: Replaces the courses ME-E3300 / Inf-0.1300 Estetiikka.
Evaluation: 0-5
Language of Instruction: English
Further Information: The course is primarily offered for the students of the Degree Programme of Information Networks. Limited acceptance for other students, based on the lecturer`s judgement.

CS-E5600 Aesthetics (3 sp)

Kursnivå: Master's level
Undervisningsperiod: III – V (Spring)III – V (Spring)
Arbetsmängd: Lectures 9 h, workshops 30 h, independent work in groups.

Lärandemål: The student understands different conceptions of beauty, how they relate to historical periods, and theoretical assertions based on philosophical and artistic investigation of sensation.
Innehåll: Introduction to basic concepts of aesthetics through realizations of garden design, the sensory ideal in the western world. The practicum of aesthetics texts covers the central concepts of aesthetics from mimesis to post-modern. As project work, students working in groups design “today’s garden” reflecting their views and values.
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Ersättande prestationer: Replaces the courses ME-E3300 / Inf-0.1300 Estetiikka.
Bedömningsskala: 0-5
Undervisningsspråk: English
Tilläggsinformation: The course is primarily offered for the students of the Degree Programme of Information Networks. Limited acceptance for other students, based on the lecturer`s judgement.

CS-E5600 Aesthetics (3 cr)

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Substitutes for Courses: Replaces the courses ME-E3300 / Inf-0.1300 Estetiikka.
Grading Scale: 0-5
Language of Instruction: English
Further Information: The course is primarily offered for the students of the Degree Programme of Information Networks. Limited acceptance for other students, based on the lecturer`s judgement.

CS-E5610 Social Media (4 cr)

Responsible teacher: Tapio Takala; Risto Sarvas
Teaching period: I – II (Autumn 2016)
Workload: Lectures 20 h and group work.
Learning Outcomes: After taking this course the student can apply societal perspectives into designing and analysing social media.
Content: The goal of this course is to give a general view of so called social media as a socio-technical phenomenon. In this course, the concept of 'social' refers to the society more than to social interaction. The focus points are the background and history of the social media, the impacts on people and their networks, the significance in politics and journalism, related ethical issues, and new uses for social media in communication and product development. The course includes an assignment where the students design a social media service, product or application.
Assessment Methods and Criteria: Lectures, weekly exercises and a group assignment.
Study Material: To be announced later in course web page.
Evaluation: 0-5
Language of Instruction: English

CS-E5610 Social Media (4 sp)

Ansvarig lärare: Tapio Takala; Risto Sarvas
Undervisningsperiod: I – II (Autumn 2016)
Arbetsmängd: Lectures 20 h and group work.
Lärandemål: After taking this course the student can apply societal perspectives into designing and analysing social media.
Innehåll: The goal of this course is to give a general view of so called social media as a socio-technical phenomenon. In this course, the concept of 'social' refers to the society more than to social interaction. The focus points are the background and history of the social media, the impacts on people and their networks, the significance in politics and journalism, related ethical issues, and new uses for social media in communication and product development. The course includes an assignment where the students design a social media service, product or application.
Metoder, arbetssätt och bedömningsgrunder: Lectures, weekly exercises and a group assignment.
Studiematerial: To be announced later in course web page.
Bedömningsskala: 0-5
Undervisningsspråk: English

CS-E5610 Social Media (4 cr)

Responsible teacher: Tapio Takala; Risto Sarvas
Teaching Period: I – II (Autumn 2016)
Workload: Lectures 20 h and group work.
Learning Outcomes: After taking this course the student can apply societal

perspectives into designing and analysing social media.
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Assessment Methods and Criteria: Lectures, weekly exercises and a group assignment.
Study Material: To be announced later in course web page.
Grading Scale: 0-5
Language of Instruction: English

CS-E5700 Hands-on Network Analysis (5 cr)

Responsible teacher: Jari Saramäki
Status of the Course: Master's Programme in Life Science Technologies, optional course of major Complex Systems
Level of the Course: Master's level
Teaching period: IV-V (Spring)
Workload: Contact teaching and group work (6 x 4 h), independent studying (research articles), independent group work
Learning Outcomes: This course is intended to be taken after Becs-114.4150 Complex Networks; it will deepen the students' knowledge on network analysis techniques and dealing with empirical network data, including network visualization, Python programming, and statistical analysis.
Substitutes for Courses: Replaces the former course BECS-E4200 Hands-on Network Analysis.
Prerequisites: Compulsory: CS-E5740 / Becs-114.4150 Complex Networks.
Evaluation: Pass/fail
Language of Instruction: English
Further Information: Number of students is limited and the prerequisite course is compulsory.

CS-E5700 Hands-on Network Analysis (5 sp)

Ansvarig lärare: Jari Saramäki
Kursens status: Master's Programme in Life Science Technologies, optional course of major Complex Systems
Kursnivå: Master's level
Undervisningsperiod: IV-V (Spring)
Arbetsmängd: Contact teaching and group work (6 x 4 h), independent studying (research articles), independent group work
Lärandemål: This course is intended to be taken after Becs-114.4150 Complex Networks; it will deepen the students' knowledge on network analysis techniques and dealing with empirical network data, including network visualization, Python

programming, and statistical analysis.
Ersättande prestationer: Replaces the former course BECS-E4200 Hands-on Network Analysis.
Förkunskaper: Compulsory: CS-E5740 / Becs-114.4150 Complex Networks.
Bedömningsskala: Pass/fail
Undervisningsspråk: English
Tilläggsinformation: Number of students is limited and the prerequisite course is compulsory.

CS-E5700 Hands-on Network Analysis (5 cr)

Responsible teacher: Jari Saramäki
Status of the Course: Master's Programme in Life Science Technologies, optional course of major Complex Systems
Level of the Course: Master's level
Teaching Period: IV-V (Spring)
Workload: Contact teaching and group work (6 x 4 h), independent studying (research articles), independent group work
Learning Outcomes: This course is intended to be taken after Becs-114.4150 Complex Networks; it will deepen the students' knowledge on network analysis techniques and dealing with empirical network data, including network visualization, Python programming, and statistical analysis.
Substitutes for Courses: Replaces the former course BECS-E4200 Hands-on Network Analysis.
Prerequisites: Compulsory: CS-E5740 / Becs-114.4150 Complex Networks.
Grading Scale: Pass/fail
Language of Instruction: English
Further Information: Number of students is limited and the prerequisite course is compulsory.

CS-E5710 Bayesian Data Analysis (5 cr)

Responsible teacher: Aki Vehtari
Status of the Course: Master's Programme in Life Science Technologies, compulsory course of major Human Neuroscience and -technology and optional course of major Complex Systems.
Level of the Course: Master's level
Teaching period: I-II (Autumn)
Workload: Lectures 10x2h, computer exercises 10x2h, independent studying (text book, programming, home exercise report), final exam
Learning Outcomes: After the course, the student can explain the central concepts in Bayesian statistics, and name steps of the Bayesian modeling process. The student can recognize usages for common (i.e. those presented during the course) statistical models, and formulate the models in these situations. The student can compare the most popular Bayesian simulation methods, and implement them. The student can use analytic and simulation based methods for learning the parameters of a given model. The student can estimate the fit of a model to data and compare models.

Content: Bayesian probability theory and bayesian inference. Bayesian models and their analysis. Computational methods, Markov-Chain Monte Carlo.
Substitutes for Courses: Replaces courses BECS-E2601 Bayesian Data Analysis, Becs-114.2601 Bayesian Modelling and Becs-114.1311 Introduction to Bayesian Statistics.
Evaluation: 0 - 5
Language of Instruction: English

CS-E5710 Bayesian Data Analysis (5 sp)

Ansvarig lärare: Aki Vehtari
Kursens status: Master's Programme in Life Science Technologies, compulsory course of major Human Neuroscience and -technology and optional course of major Complex Systems.
Kursnivå: Master's level
Undervisningsperiod: I-II (Autumn)
Arbetsmängd: Lectures 10x2h, computer exercises 10x2h, independent studying (text book, programming, home exercise report), final exam
Lärandemål: After the course, the student can explain the central concepts in Bayesian statistics, and name steps of the Bayesian modeling process. The student can recognize usages for common (i.e. those presented during the course) statistical models, and formulate the models in these situations. The student can compare the most popular Bayesian simulation methods, and implement them. The student can use analytic and simulation based methods for learning the parameters of a given model. The student can estimate the fit of a model to data and compare models.
Innehåll: Bayesian probability theory and bayesian inference. Bayesian models and their analysis. Computational methods, Markov-Chain Monte Carlo.
Ersättande prestationer: Replaces courses BECS-E2601 Bayesian Data Analysis, Becs-114.2601 Bayesian Modelling and Becs-114.1311 Introduction to Bayesian Statistics.
Bedömningsskala: 0 - 5
Undervisningsspråk: English

CS-E5710 Bayesian Data Analysis (5 cr)

Responsible teacher: Aki Vehtari
Status of the Course: Master's Programme in Life Science Technologies, compulsory course of major Human Neuroscience and -technology and optional course of major Complex Systems.
Level of the Course: Master's level
Teaching Period: I-II (Autumn)
Workload: Lectures 10x2h, computer exercises 10x2h, independent studying (text book, programming, home exercise report), final exam
Learning Outcomes: After the course, the student can explain the central concepts in Bayesian statistics, and name steps of the Bayesian modeling process. The student can recognize usages for common (i.e. those presented during the course) statistical models, and formulate the models in these situations. The

student can compare the most popular Bayesian simulation methods, and implement them. The student can use analytic and simulation based methods for learning the parameters of a given model. The student can estimate the fit of a model to data and compare models.
Content: Bayesian probability theory and bayesian inference. Bayesian models and their analysis. Computational methods, Markov-Chain Monte Carlo.
Substitutes for Courses: Replaces courses BECS-E2601 Bayesian Data Analysis, Becs-114.2601 Bayesian Modelling and Becs-114.1311 Introduction to Bayesian Statistics.
Grading Scale: 0 - 5
Language of Instruction: English

CS-E5720 Work Course on Bayesian Analysis (2 cr)

Responsible teacher: Aki Vehtari
Teaching period: IV, V (Spring)
Content: Linear model, generalized linear model, ANOVA, multilevel/hierarchical model.
Assessment Methods and Criteria: Project work.
Study Material: Course book or a collection of articles, will be published at the beginning of the course.
Substitutes for Courses: Replaces the former course BECS-114.5312 Work Course on Bayesian Analysis.
Prerequisites: CS-E571 Bayesian data analysis
Evaluation: pass/fail
Language of Instruction: English

CS-E5720 Work Course on Bayesian Analysis (2 sp)

Ansvarig lärare: Aki Vehtari
Undervisningsperiod: IV, V (Spring)
Innehåll: Linear model, generalized linear model, ANOVA, multilevel/hierarchical model.
Metoder, arbetssätt och bedömningsgrunder: Project work.
Studiematerial: Course book or a collection of articles, will be published at the beginning of the course.
Ersättande prestationer: Replaces the former course BECS-114.5312 Work Course on Bayesian Analysis.
Förkunskaper: CS-E5710 Bayesian data analysis
Bedömningsskala: pass/fail
Undervisningsspråk: English

CS-E5720 Work Course on Bayesian Analysis (2 cr)

Responsible teacher: Aki Vehtari
Teaching Period: IV, V (Spring)
Content: Linear model, generalized linear model, ANOVA, multilevel/hierarchical model.

Assessment Methods and Criteria: Project work.
Study Material: Course book or a collection of articles, will be published at the beginning of the course.
Substitutes for Courses: Replaces the former course BECS-114.5312 Work Course on Bayesian Analysis.
Prerequisites: CS-E5710 Bayesian data analysis
Grading Scale: pass/fail
Language of Instruction: English

CS-E5730 Mathematical Modelling of Social Dynamics (5 cr)

Responsible teacher: Santo Fortunato
Level of the Course: Master's and doctoral level
Teaching period: II (odd years)
Workload: The course consists of lectures, assignments given after each lecture, and a project work.
Content: The course is an introduction to a recent very active research topic, that is growing in terms of visibility and impact. The idea of a rigorous quantitative modelling of social dynamics, which could match the stunning successes that Newton's laws had reached in physics, has had a long history and many illustrious fathers, from political philosophers like Thomas Hobbes, Auguste Compte and Stuart Mill, to scientists like Condorcet, Petty and Quetelet. However, only in the last decade, with the increasing availability of large datasets on social phenomena and ofmassive computational facilities, it has finally become possible to implement this idea.The goal of this course is to make the students acquainted with this new and fascinating research topic, and to provide them the necessary set of tools to make them able to work in this area. The students will learn how birds organize their motion in ordered flocks, or how pedestrians behave in panic situations. We will also see how consensus emerges from a multitude of individuals who initially have very different opinions, or how languages compete with each other like animal species.
Being fairly new, this discipline offers many directions for potential contributions, especially from young people, in contrast to what usually happens for established topics. It is possible that projects developed by the students at the end of the course may turn into scientific publications in international journals.
Substitutes for Courses: Replaces the former course BECS-E4101 Mathematical Modelling of Social Dynamics.
Prerequisites: Basic maths (calculus, linear algebra, probability and statistics). Programming skills are required to complete the project work. Knowledge of statistical physics is helpful but not mandatory.
Evaluation: 0-5
Registration for Courses: Registration via WebOodi.
Language of Instruction: English

CS-E5730 Mathematical Modelling of Social Dynamics (5 sp)

Ansvarig lärare: Santo Fortunato
Kursnivå: Master's and doctoral level

Undervisningsperiod: II (odd years)
Arbetsmängd: The course consists of lectures, assignments given after each lecture, and a project work.
Innehåll: The course is an introduction to a recent very active research topic, that is growing in terms of visibility and impact. The idea of a rigorous quantitative modelling of social dynamics, which could match the stunning successes that Newton's laws had reached in physics, has had a long history and many illustrious fathers, from political philosophers like Thomas Hobbes, Auguste Compte and Stuart Mill, to scientists like Condorcet, Petty and Quetelet. However, only in the last decade, with the increasing availability of large datasets on social phenomena and ofmassive computational facilities, it has finally become possible to implement this idea.The goal of this course is to make the students acquainted with this new and fascinating research topic, and to provide them the necessary set of tools to make them able to work in this area. The students will learn how birds organize their motion in ordered flocks, or how pedestrians behave in panic situations. We will also see how consensus emerges from a multitude of individuals who initially have very different opinions, or how languages compete with each other like animal species.
Being fairly new, this discipline offers many directions for potential contributions, especially from young people, in contrast to what usually happens for established topics. It is possible that projects developed by the students at the end of the course may turn into scientific publications in international journals.
Ersättande prestationer: Replaces the former course BECS-E4101 Mathematical Modelling of Social Dynamics.
Förkunskaper: Basic maths (calculus, linear algebra, probability and statistics). Programming skills are required to complete the project work. Knowledge of statistical physics is helpful but not mandatory.
Bedömningsskala: 0-5
Anmälning: Registration via WebOodi.
Undervisningsspråk: English

CS-E5730 Mathematical Modelling of Social Dynamics (5 cr)

Responsible teacher: Santo Fortunato
Level of the Course: Master's and doctoral level
Teaching Period: II (odd years)
Workload: The course consists of lectures, assignments given after each lecture, and a project work.
Content: The course is an introduction to a recent very active research topic, that is growing in terms of visibility and impact. The idea of a rigorous quantitative modelling of social dynamics, which could match the stunning successes that Newton's laws had reached in physics, has had a long history and many illustrious fathers, from political philosophers like Thomas Hobbes, Auguste Compte and Stuart Mill, to scientists like Condorcet, Petty and Quetelet. However, only in the last decade, with the increasing availability of large datasets on social phenomena and ofmassive computational facilities, it has finally become possible to implement this idea.The goal of this course is to make the students acquainted

with this new and fascinating research topic, and to provide them the necessary set of tools to make them able to work in this area. The students will learn how birds organize their motion in ordered flocks, or how pedestrians behave in panic situations. We will also see how consensus emerges from a multitude of individuals who initially have very different opinions, or how languages compete with each other like animal species.
Being fairly new, this discipline offers many directions for potential contributions, especially from young people, in contrast to what usually happens for established topics. It is possible that projects developed by the students at the end of the course may turn into scientific publications in international journals.
Substitutes for Courses: Replaces the former course BECS-E4101 Mathematical Modelling of Social Dynamics.
Prerequisites: Basic maths (calculus, linear algebra, probability and statistics). Programming skills are required to complete the project work. Knowledge of statistical physics is helpful but not mandatory.
Grading Scale: 0-5
Registration for Courses: Registration via WebOodi.
Language of Instruction: English

CS-E5740 Complex Networks(V) (5 cr)

Responsible teacher: Jari Saramäki
Teaching period: II (Autumn)
Workload: 12 + 12 + 12
Learning Outcomes: This course will provide students with fundamentals of complex network theory, together with skills for applying this knowledge in to practical network analysis.
Content: Introduction to complex networks, fundamentals and basic concepts. Fundamental models: random networks, small-world networks, and scale-free networks. Network measures and analysis.
Assessment Methods and Criteria: Grades are given on the basis of weekly mandatory exercises and project work, there is no exam. Exercises and project work require Python programming - you do not need to be familiar with Python beforehand, we will give tutorials, however some programming skills are needed.
Substitutes for Courses: Replaces the former course BECS-114.4150 Complex Networks.
Evaluation: 0-5
Language of Instruction: English

CS-E5740 Complex Networks(V) (5 sp)

Ansvarig lärare: Jari Saramäki
Undervisningsperiod: II (Autumn)
Arbetsmängd: 12 + 12 + 12
Lärandemål: This course will provide students with fundamentals of complex network theory, together with skills for applying this knowledge in to practical network analysis.
Innehåll: Introduction to complex networks, fundamentals and basic concepts.

Fundamental models: random networks, small-world networks, and scale-free networks. Network measures and analysis.
Metoder, arbetssätt och bedömningsgrunder: Grades are given on the basis of weekly mandatory exercises and project work, there is no exam. Exercises and project work require Python programming - you do not need to be familiar with Python beforehand, we will give tutorials, however some programming skills are needed.
Ersättande prestationer: Replaces the former course BECS-114.4150 Complex Networks.
Bedömningsskala: 0-5
Undervisningsspråk: English

CS-E5740 Complex Networks(V) (5 cr)

Responsible teacher: Jari Saramäki
Teaching Period: II (Autumn)
Workload: 12 + 12 + 12
Learning Outcomes: This course will provide students with fundamentals of complex network theory, together with skills for applying this knowledge in to practical network analysis.
Content: Introduction to complex networks, fundamentals and basic concepts. Fundamental models: random networks, small-world networks, and scale-free networks. Network measures and analysis.
Assessment Methods and Criteria: Grades are given on the basis of weekly mandatory exercises and project work, there is no exam. Exercises and project work require Python programming - you do not need to be familiar with Python beforehand, we will give tutorials, however some programming skills are needed.
Substitutes for Courses: Replaces the former course BECS-114.4150 Complex Networks.
Grading Scale: 0-5
Language of Instruction: English

CS-E5750 Nonlinear Dynamics and Chaos (3-5 cr)

Responsible teacher: Santo Fortunato
Status of the Course: Optional course of major Complex Systems.
Teaching period: iii (Spring)
Content: Flows on the line. Bifurcations. Flows on the plane. Limit cycles. Lorenz equations. One-dimensional maps. Logistic maps. Lyapunov exponents. Fractals.
Assessment Methods and Criteria: Final examination and mathematical/computational exercises.
Study Material: S. H. Strogatz, Nonlinear dynamics and chaos. Specific articles may be added.
Substitutes for Courses: Replaces the former course BECS-114.7151 Nonlinear Dynamics and Chaos.
Prerequisites: The student should be familiar with differential equations, linear algebra, and programming.

Evaluation: 0-5
Language of Instruction: English
Further Information: This course is for Master's students and graduate students.

CS-E5750 Nonlinear Dynamics and Chaos (3-5 sp)

Ansvarig lärare: Santo Fortunato
Kursens status: Optional course of major Complex Systems.
Undervisningsperiod: iii (Spring)
Innehåll: Flows on the line. Bifurcations. Flows on the plane. Limit cycles. Lorenz equations. One-dimensional maps. Logistic maps. Lyapunov exponents. Fractals.
Metoder, arbetssätt och bedömningsgrunder: Final examination and mathematical/computational exercises.
Studiematerial: S. H. Strogatz, Nonlinear dynamics and chaos. Specific articles may be added.
Ersättande prestationer: Replaces the former course BECS-114.7151 Nonlinear Dynamics and Chaos.
Förkunskaper: The student should be familiar with differential equations, linear algebra, and programming.
Bedömningsskala: 0-5
Undervisningsspråk: English
Tilläggsinformation: This course is for Master's students and graduate students.

CS-E5750 Nonlinear Dynamics and Chaos (3-5 cr)

Responsible teacher: Santo Fortunato
Status of the Course: Optional course of major Complex Systems.
Teaching Period: iii (Spring)
Content: Flows on the line. Bifurcations. Flows on the plane. Limit cycles. Lorenz equations. One-dimensional maps. Logistic maps. Lyapunov exponents. Fractals.
Assessment Methods and Criteria: Final examination and mathematical/computational exercises.
Study Material: S. H. Strogatz, Nonlinear dynamics and chaos. Specific articles may be added.
Substitutes for Courses: Replaces the former course BECS-114.7151 Nonlinear Dynamics and Chaos.
Prerequisites: The student should be familiar with differential equations, linear algebra, and programming.
Grading Scale: 0-5
Language of Instruction: English
Further Information: This course is for Master's students and graduate students.

CS-E5770 Special Course in Complex Systems(V) (3-6 cr)

Responsible teacher: Jari Saramäki
Level of the Course: Master's level

Teaching period: Announced later
Learning Outcomes: You are familiar with some scientifically or technically demanding topic.
Content: This course has a varying topic. The content of the course is a selected current topic areas in complex systems. When arranged, the course may be given in English. Information about the arrangement and the beginning of the course will be published in the web pages.
Assessment Methods and Criteria: Announced later.
Evaluation: 0-5, may also be graded with pass/fail.
Language of Instruction: English or Finnish.
Further Information: The content of the course varies.

CS-E5770 Special Course in Complex Systems(V) (3-6 sp)

Ansvarig lärare: Jari Saramäki
Kursnivå: Master's level
Undervisningsperiod: Announced later
Lärandemål: You are familiar with some scientifically or technically demanding topic.
Innehåll: This course has a varying topic. The content of the course is a selected current topic areas in complex systems. When arranged, the course may be given in English. Information about the arrangement and the beginning of the course will be published in the web pages.
Metoder, arbetssätt och bedömningsgrunder: Announced later.
Bedömningsskala: 0-5, may also be graded with pass/fail.
Undervisningsspråk: English or Finnish.
Tilläggsinformation: The content of the course varies.

CS-E5770 Special Course in Complex Systems(V) (3-6 cr)

Responsible teacher: Jari Saramäki
Level of the Course: Master's level
Teaching Period: Announced later
Learning Outcomes: You are familiar with some scientifically or technically demanding topic.
Content: This course has a varying topic. The content of the course is a selected current topic areas in complex systems. When arranged, the course may be given in English. Information about the arrangement and the beginning of the course will be published in the web pages.
Assessment Methods and Criteria: Announced later.
Grading Scale: 0-5, may also be graded with pass/fail.
Language of Instruction: English or Finnish.
Further Information: The content of the course varies.

CS-E5780 Special Assignment in Complex Systems (5-10 cr)

Responsible teacher: Riku Linna; Aki Vehtari; Jari Saramäki
Status of the Course: Master's Programme in Life Science Technologies,

optional course of major Complex Systems
Level of the Course: Master's level
Teaching period: I, II, III, IV, V (Autumn & Spring)
Workload: Independent project work (literature survey, design, implementation, and write-up)
Content: This courses comprises an individual project work and an oral presentation on a chosen complex systems topic. The project work may involve a literature survey, theoretical studies and/or data analysis.
Evaluation: 0 - 5
Language of Instruction: English

CS-E5780 Special Assignment in Complex Systems (5-10 sp)

Ansvarig lärare: Riku Linna; Aki Vehtari; Jari Saramäki
Kursens status: Master's Programme in Life Science Technologies, optional course of major Complex Systems
Kursnivå: Master's level
Undervisningsperiod: I, II, III, IV, V (Autumn & Spring)
Arbetsmängd: Independent project work (literature survey, design, implementation, and write-up)
Innehåll: This courses comprises an individual project work and an oral presentation on a chosen complex systems topic. The project work may involve a literature survey, theoretical studies and/or data analysis.
Bedömningsskala: 0 - 5
Undervisningsspråk: English

CS-E5780 Special Assignment in Complex Systems (5-10 cr)

Responsible teacher: Riku Linna; Aki Vehtari; Jari Saramäki
Status of the Course: Master's Programme in Life Science Technologies, optional course of major Complex Systems
Level of the Course: Master's level
Teaching Period: I, II, III, IV, V (Autumn & Spring)
Workload: Independent project work (literature survey, design, implementation, and write-up)
Content: This courses comprises an individual project work and an oral presentation on a chosen complex systems topic. The project work may involve a literature survey, theoretical studies and/or data analysis.
Grading Scale: 0 - 5
Language of Instruction: English

CS-E5790 Computational Science (5 cr)

Responsible teacher: Riku Linna
Status of the Course: Optional course of major Complex Systems.
Teaching period: I - II (Autumn)
Workload: 26+26
Content: Introduction to numerical mathematics and modeling. Numerical

interpolation, curve fitting, integration and optimization.
Data fitting and filtering. Solving systems of linear equations. Basics of the Monte Carlo and Molecular Dynamics methods.
Computer exercises.
Assessment Methods and Criteria: Examination and mathematical exercises.
Study Material: Lecture material and given articles/references. W.Cheney and D. Kincaid: Numerical mathematics and computing. 4th ed. Brooks/Cole (1999) and W.H.Press, S.A.Teukolsky, W.T.Vetterling & B.P.Flannery: Numerical Recipes (in C++/Fortran), The Art of Scientific Computing, 2nd edition, Cambridge University Press (1992, 2002).
Substitutes for Courses: Replaces courses BECS-114.1100 Computational Science, S-114.100 and S-114.1100.
Prerequisites: The student should be familiar with programming (preferably FORTRAN or C). Basic (first-year) mathematics and familiarity with programming in some language, e.g. python, C, C++, or FORTRAN.
Evaluation: 0-5
Language of Instruction: English

CS-E5790 Computational Science (5 sp)

Ansvarig lärare: Riku Linna
Kursens status: Optional course of major Complex Systems.
Undervisningsperiod: I - II (Autumn)
Arbetsmängd: 26+26
Innehåll: Introduction to numerical mathematics and modeling. Numerical interpolation, curve fitting, integration and optimization.
Data fitting and filtering. Solving systems of linear equations. Basics of the Monte Carlo and Molecular Dynamics methods.
Computer exercises.
Metoder, arbetssätt och bedömningsgrunder: Examination and mathematical exercises.
Studiematerial: Lecture material and given articles/references. W.Cheney and D. Kincaid: Numerical mathematics and computing. 4th ed. Brooks/Cole (1999) and W.H.Press, S.A.Teukolsky, W.T.Vetterling & B.P.Flannery: Numerical Recipes (in C++/Fortran), The Art of Scientific Computing, 2nd edition, Cambridge University Press (1992, 2002).
Ersättande prestationer: Replaces courses BECS-114.1100 Computational Science, S-114.100 and S-114.1100.
Förkunskaper: The student should be familiar with programming (preferably FORTRAN or C). Basic (first-year) mathematics and familiarity with programming in some language, e.g. python, C, C++, or FORTRAN.
Bedömningsskala: 0-5
Undervisningsspråk: English

CS-E5790 Computational Science (5 cr)

Responsible teacher: Riku Linna
Status of the Course: Optional course of major Complex Systems.

Teaching Period: I - II (Autumn)
Workload: 26+26
Content: Introduction to numerical mathematics and modeling. Numerical interpolation, curve fitting, integration and optimization.
Data fitting and filtering. Solving systems of linear equations. Basics of the Monte Carlo and Molecular Dynamics methods.
Computer exercises.
Assessment Methods and Criteria: Examination and mathematical exercises.
Study Material: Lecture material and given articles/references. W.Cheney and D. Kincaid: Numerical mathematics and computing. 4th ed. Brooks/Cole (1999) and W.H.Press, S.A.Teukolsky, W.T.Vetterling & B.P.Flannery: Numerical Recipes (in C++/Fortran), The Art of Scientific Computing, 2nd edition, Cambridge University Press (1992, 2002).
Substitutes for Courses: Replaces courses BECS-114.1100 Computational Science, S-114.100 and S-114.1100.
Prerequisites: The student should be familiar with programming (preferably FORTRAN or C). Basic (first-year) mathematics and familiarity with programming in some language, e.g. python, C, C++, or FORTRAN.
Grading Scale: 0-5
Language of Instruction: English

CS-E5800 Seminar on Computational Engineering(V) (3 cr)

Responsible teacher: Riku Linna
Teaching period: III - IV (Spring)
Content: Practical work preparing a representation.
Assessment Methods and Criteria: Term paper and report, active participation to the seminar.
Substitutes for Courses: Replaces former courses BECS-114.2240, S-114.240, S-114.2502, S-114.2240 and Becs-114.4245.
Evaluation: 0-5
Language of Instruction: English
Further Information: The content of the course varies.

CS-E5800 Seminar on Computational Engineering(V) (3 sp)

Ansvarig lärare: Riku Linna
Undervisningsperiod: III - IV (Spring)
Innehåll: Practical work preparing a representation.
Metoder, arbetssätt och bedömningsgrunder: Term paper and report, active participation to the seminar.
Ersättande prestationer: Replaces former courses BECS-114.2240, S-114.240, S-114.2502, S-114.2240 and Becs-114.4245.
Bedömningsskala: 0-5
Undervisningsspråk: English
Tilläggsinformation: The content of the course varies.

CS-E5800 Seminar on Computational Engineering(V) (3 cr)

Responsible teacher: Riku Linna
Teaching Period: III - IV (Spring)
Content: Practical work preparing a representation.
Assessment Methods and Criteria: Term paper and report, active participation to the seminar.
Substitutes for Courses: Replaces former courses BECS-114.2240, S-114.240, S-114.2502, S-114.2240 and Becs-114.4245.
Grading Scale: 0-5
Language of Instruction: English
Further Information: The content of the course varies.

CS-E5810 Laskennallisen tekniikan erikoistyö (3-8 op)

Vastuuopettaja: Santo Fortunato; Jukka Tulkki; Jouko Lampinen; Kimmo Kaski; Mikko Sams; Jari Saramäki
Opetusperiodi: I, II, III, IV, V
Sisältö: Kurssi koostuu laskennallisen tekniikan aihepiiriin liittyvästä erikoistyöstä.
Oppimateriaali: Työmonisteet.
Korvaavuudet: Korvaa opintojakson BECS-114.3215, S-114.215, S-114.3215 ja Becs-114.3520.
Arvosteluasteikko: 0-5
Opetuskieli: Finnish. Can be taken in English upon request.

CS-E5810 Specialproject i datorbaserad teknik (3-8 sp)

Ansvarig lärare: Santo Fortunato; Jukka Tulkki; Jouko Lampinen; Kimmo Kaski; Mikko Sams; Jari Saramäki
Undervisningsperiod: I, II, III, IV, V
Innehåll: Kursen består av arbeten, som anknyter sig till olika ämnesområden inom datorbaserad teknik.
Studiematerial: Kurskompendier.
Ersättande prestationer: Ersätter kurser BECS-114.3215, S-114.215, S-114.3215 ja Becs-114.3520.
Bedömningsskala: 0-5
Undervisningsspråk: Finnish. Can be taken in English upon request.

CS-E5810 Special Project in Computational Engineering (3-8 cr)

Responsible teacher: Santo Fortunato; Jukka Tulkki; Jouko Lampinen; Kimmo Kaski; Mikko Sams; Jari Saramäki
Teaching Period: I, II, III, IV, V
Content: Special project related to computational engineering.
Study Material: Course handouts.
Substitutes for Courses: Replaces courses BECS-114.3215, S-114.215, S-114.3215 ja Becs-114.3520.
Grading Scale: 0-5
Language of Instruction: Finnish. Can be taken in English upon request.

CS-E5820 Laskennallisen tekniikan erikoiskurssi II(V) (3-6 op)

Vastuuopettaja: Jouko Lampinen
Opetusperiodi: I, II, III, IV, V
Sisältö: Kurssin sisältö vaihtelee vuosittain. Kurssin tavoitteena on antaa lisensiaattitasoista opetusta laskennalliseen tekniikkaan liittyvästä aihepiiristä. Kurssi voi olla luento- tai seminaarimuotoinen.
Toteutus, työmuodot ja arvosteluperusteet: Suoritustavasta sovitaan erikseen vuosittain.
Oppimateriaali: Oppikirja tai kokoelma artikkeleita, ilmoitetaan kurssin alussa.
Korvaavuudet: Korvaa kurssit BECS-114.4202, S-114.202, S-114.4202 ja Becs-114.4203.
Arvosteluasteikko: 0-5
Opetuskieli: Suomi. Pyydettäessä suoritettavissa englanniksi.
Lisätietoja: Vaihtuvasisältöinen.

CS-E5820 Specialkurs i datorbaserad teknik II(V) (3-6 sp)

Ansvarig lärare: Jouko Lampinen
Undervisningsperiod: I, II, III, IV, V
Innehåll: Kursens innehåll varierar årligen. Kursens mål är att ge undervisning på licentiatsnivå i något delområde inom datorbaserad teknik. Kursen kan bestå av föreläsningar eller seminarier.
Metoder, arbetssätt och bedömningsgrunder: Uppges i början av kursen.
Studiematerial: Lärobok eller udrag av publikationer, uppges i början av kursen.
Ersättande prestationer: Ersätter kurser BECS-114.4202, S-114.202, S-114.4202 och Becs-114.4203.
Bedömningsskala: 0-5
Undervisningsspråk: Finska. Kan på begäran avläggas på engelska.
Tilläggsinformation: Kursens innehåll varierar.

CS-E5820 Special Course in Computational Engineering II(V) (3-6 cr)

Responsible teacher: Jouko Lampinen
Teaching Period: I, II, III, IV, V
Content: The contents of course vary yearly. The aim of the course is to give licensiate level teaching on a topic related to computational technology. The course may be given as lectures or as a seminar course.
Assessment Methods and Criteria: To be discussed with the teacher.
Study Material: Course book or a collection of articles, will be published at the beginning of the course.
Substitutes for Courses: Replaces courses BECS-114.4202, S-114.202, S-114.4202 and Becs-114.4203.
Grading Scale: 0-5
Language of Instruction: Finnish. Can be taken in English upon request.
Further Information: The content of the course varies.

CS-E5830 Laskennallisen tieteen tutkijaseminaari(V) (3-6 op)

Vastuuopettaja: Jouko Lampinen
Opetusperiodi: I - II, III - IV
Sisältö: Vuosittain vaihtuva aihe liittyy johonkin ajankohtaiseen laskennallisen tekniikan alan tutkimusongelmaan.
Toteutus, työmuodot ja arvosteluperusteet: Aktiivinen osallistuminen ja seminaariesitelmien pitäminen.
Korvaavuudet: Korvaa kurssit BECS-114.4220, S-114.220 ja S-114.3503, S-114.4220.
Arvosteluasteikko: 0-5
Opetuskieli: Suomi. Pyydettäessä suoritettavissa englanniksi.
Lisätietoja: Vaihtuvasisältöinen. Järjestetään tarvittaessa sekä I-II että III-IV periodeilla.

CS-E5830 Forskningseminarium i datorbaserad vetenskap(V) (3-6 sp)

Ansvarig lärare: Jouko Lampinen
Undervisningsperiod: I - II, III - IV
Innehåll: Årligen varierande seminarium behandlar något aktuellt forskningsproblem i datorbaserad teknik.
Metoder, arbetssätt och bedömningsgrunder: Seminarieföredrag och rapport samt aktiv deltagande i seminariet.
Ersättande prestationer: Ersätter kurser BECS-114.4220, S-114.220 ja S-114.3503, S-114.4220.
Bedömningsskala: 0-5
Undervisningsspråk: Finska. Kan på begäran avläggas på engelska.
Tilläggsinformation: Kursens innehåll varierar. Arrangerads vid behov båda i periods I-II och III-IV.

CS-E5830 Research Seminar on Computational Science(V) (3-6 cr)

Responsible teacher: Jouko Lampinen
Teaching Period: I - II, III - IV
Content: Course with varying content.
Assessment Methods and Criteria: Seminar presentation, report and active participation.
Substitutes for Courses: Replaces courses BECS-114.4220, S-114.220 ja S-114.3503, S-114.4220.
Grading Scale: 0-5
Language of Instruction: Finnish. Can be taken in English upon request.
Further Information: The content of the course varies. Can be arranged both in periods I-II and III-IV if necessary.

CS-E5840 Yksilöllisiä laskennallisen tekniikan opintoja(V) (1-8 op)

Vastuuopettaja: Riku Linna; Santo Fortunato; Jukka Tulkki; Aki Vehtari; Jouko Lampinen; Kimmo Kaski; Jari Saramäki
Opetusperiodi: I, II, III, IV, V

Sisältö: Yksilöllisten opintojen sisällöstä ja laajuudesta sovitaan vastaavan opettajan kanssa etukäteen.
Korvaavuudet: Korvaa kurssit BECS-114.4230, S-114.230, S-114.4230.
Arvosteluasteikko: 0-5
Opetuskieli: Suomi. Pyydettäessä suoritettavissa englanniksi.
Lisätietoja: Vaihtuvasisältöinen.

CS-E5840 Individuell studieperiod i datorbaserad teknik(V) (1-8 sp)

Ansvarig lärare: Riku Linna; Santo Fortunato; Jukka Tulkki; Aki Vehtari; Jouko Lampinen; Kimmo Kaski; Jari Saramäki
Undervisningsperiod: I, II, III, IV, V
Innehåll: Den individuella studieperiodens mål och omfattning görs upp med den ansvariga läraren.
Ersättande prestationer: Ersätter kurser BECS-114.4230, S-114.230, S-114.4230.
Bedömningsskala: 0-5
Undervisningsspråk: Finska. Kan på begäran avläggas på engelska.
Tilläggsinformation: Kursens innehåll varierar.

CS-E5840 Individual Studies on Computational Engineering(V) (1-8 cr)

Responsible teacher: Riku Linna; Santo Fortunato; Jukka Tulkki; Aki Vehtari; Jouko Lampinen; Kimmo Kaski; Jari Saramäki
Teaching Period: I, II, III, IV, V
Content: The topic and its depth shall be negotiated with one of the teachers.
Substitutes for Courses: Replaces courses BECS-114.4230, S-114.230, S-114.4230.
Grading Scale: 0-5
Language of Instruction: Finnish. Can be taken in English upon request.
Further Information: The content of this course varies.

CS-E5850 Individualized Studies in the Laboratories(V) (1-10 cr)

Responsible teacher: Jouko Lampinen
Teaching period: I, II (Autumn) III, IV, V (Spring)
Content: Individual assignments. To take this course, contact the responsible teacher directly in order to agree on the supervisor, topic, extent and contents of the assignment.
Substitutes for Courses: Replaces the former course BECS-114.5120.
Evaluation: 0 – 5. (Pass/Fail only if determined specifically at the start of the course/assignment.)
Registration for Courses: Contact the responsible teacher or a potential supervisor directly. See MyCourses page for further instructions.
Language of Instruction: English
Further Information: The contents of the course vary.

CS-E5850 Individualized Studies in the Laboratories(V) (1-10 sp)

Ansvarig lärare: Jouko Lampinen
Undervisningsperiod: I, II (Autumn) III, IV, V (Spring)
Innehåll: Individual assignments. To take this course, contact the responsible teacher directly in order to agree on the supervisor, topic, extent and contents of the assignment.
Ersättande prestationer: Replaces the former course BECS-114.5120.
Bedömningsskala: 0 – 5. (Pass/Fail only if determined specifically at the start of the course/assignment.)
Anmälning: Contact the responsible teacher or a potential supervisor directly. See MyCourses page for further instructions.
Undervisningsspråk: English
Tilläggsinformation: The contents of the course vary.

CS-E5850 Individualized Studies in the Laboratories(V) (1-10 cr)

Responsible teacher: Jouko Lampinen
Teaching Period: I, II (Autumn) III, IV, V (Spring)
Content: Individual assignments. To take this course, contact the responsible teacher directly in order to agree on the supervisor, topic, extent and contents of the assignment.
Substitutes for Courses: Replaces the former course BECS-114.5120.
Grading Scale: 0 – 5. (Pass/Fail only if determined specifically at the start of the course/assignment.)
Registration for Courses: Contact the responsible teacher or a potential supervisor directly. See MyCourses page for further instructions.
Language of Instruction: English
Further Information: The contents of the course vary.

CS-E5860 Computational Genomics (4-7 cr)

Responsible teacher: Juho Rousu
Level of the Course: Master's level
Teaching period: III (Spring)
Workload: 24 + 12 (4 + 2)
Learning Outcomes: The course provides you with an introduction of computational methods used in sequence and genome analysis. After the course you can design, analyze and understand real-life genomic data in computational and biomedical research groups and in industry.
Content: Algorithms and models for biological sequences and genomics.
Assessment Methods and Criteria: Examination and exercises.
Study Material: Nello Cristianini and Matthew Hahn: Introduction to Computational Genomics: A Case Studies Approach. Cambridge University Press, 2007.
Substitutes for Courses: Replaces former course T-61.5120 Computational Genomics.
Prerequisites: Basics in mathematics, statistics and computer science.
Evaluation: 0-5
Language of Instruction: English

CS-E5860 Computational Genomics (4-7 sp)

Ansvarig lärare: Juho Rousu
Kursnivå: Master's level
Undervisningsperiod: III (Spring)
Arbetsmängd: 24 + 12 (4 + 2)
Lärandemål: The course provides you with an introduction of computational methods used in sequence and genome analysis. After the course you can design, analyze and understand real-life genomic data in computational and biomedical research groups and in industry.
Innehåll: Algorithms and models for biological sequences and genomics.
Metoder, arbetssätt och bedömningsgrunder: Examination and exercises.
Studiematerial: Nello Cristianini and Matthew Hahn: Introduction to Computational Genomics: A Case Studies Approach. Cambridge University Press, 2007.
Ersättande prestationer: Replaces former course T-61.5120 Computational Genomics.
Förkunskaper: Basics in mathematics, statistics and computer science.
Bedömningsskala: 0-5
Undervisningsspråk: English

CS-E5860 Computational Genomics (4-7 cr)

Responsible teacher: Juho Rousu
Level of the Course: Master's level
Teaching Period: III (Spring)
Workload: 24 + 12 (4 + 2)
Learning Outcomes: The course provides you with an introduction of computational methods used in sequence and genome analysis. After the course you can design, analyze and understand real-life genomic data in computational and biomedical research groups and in industry.
Content: Algorithms and models for biological sequences and genomics.
Assessment Methods and Criteria: Examination and exercises.
Study Material: Nello Cristianini and Matthew Hahn: Introduction to Computational Genomics: A Case Studies Approach. Cambridge University Press, 2007.
Substitutes for Courses: Replaces former course T-61.5120 Computational Genomics.
Prerequisites: Basics in mathematics, statistics and computer science.
Grading Scale: 0-5
Language of Instruction: English

CS-E5870 High-Throughput Bioinformatics (5-7 cr)

Responsible teacher: Harri Lähdesmäki
Level of the Course: Master's level
Teaching period: I (Autumn)

Workload: 24 + 12 (4 + 2)
Learning Outcomes: The course provides you with basic understanding of high-throughput data and computational methods that are commonly used for analysing the data in biological problems. After the course you have skills to apply various computational methods in real biological problems.
Content: The course introduces computational and statistical methods for analyzing modern high-throughput biological data and their use in systems biology. Relevant high-throughput measurement technologies are reviewed during the course.
Assessment Methods and Criteria: Examination and exercise work.
Study Material: To be specified in MyCourses at the start of the course.
Substitutes for Courses: Replaces former course T-61.5050 High-Throughput Bioinformatics.
Prerequisites: Basics in mathematics, statistics and computer science.
Evaluation: 0-5
Language of Instruction: English

CS-E5870 High-Throughput Bioinformatics (5-7 sp)

Ansvarig lärare: Harri Lähdesmäki
Kursnivå: Master's level
Undervisningsperiod: I (Autumn)
Arbetsmängd: 24 + 12 (4 + 2)
Lärandemål: The course provides you with basic understanding of high-throughput data and computational methods that are commonly used for analysing the data in biological problems. After the course you have skills to apply various computational methods in real biological problems.
Innehåll: The course introduces computational and statistical methods for analyzing modern high-throughput biological data and their use in systems biology. Relevant high-throughput measurement technologies are reviewed during the course.
Metoder, arbetssätt och bedömningsgrunder: Examination and exercise work.
Studiematerial: To be specified in MyCourses at the start of the course.
Ersättande prestationer: Replaces former course T-61.5050 High-Throughput Bioinformatics.
Förkunskaper: Basics in mathematics, statistics and computer science.
Bedömningsskala: 0-5
Undervisningsspråk: English

CS-E5870 High-Throughput Bioinformatics (5-7 cr)

Responsible teacher: Harri Lähdesmäki
Level of the Course: Master's level
Teaching Period: I (Autumn)
Workload: 24 + 12 (4 + 2)
Learning Outcomes: The course provides you with basic understanding of high-throughput data and computational methods that are commonly used for analysing the data in biological problems. After the course you have skills to

apply various computational methods in real biological problems.
Content: The course introduces computational and statistical methods for analyzing modern high-throughput biological data and their use in systems biology. Relevant high-throughput measurement technologies are reviewed during the course.
Assessment Methods and Criteria: Examination and exercise work.
Study Material: To be specified in MyCourses at the start of the course.
Substitutes for Courses: Replaces former course T-61.5050 High-Throughput Bioinformatics.
Prerequisites: Basics in mathematics, statistics and computer science.
Grading Scale: 0-5
Language of Instruction: English

CS-E5880 Modeling Biological Networks(V) (5-7 cr)

Responsible teacher: Harri Lähdesmäki
Level of the Course: Master's level
Teaching period: II (Autumn)
Workload: 24 + 24 (4 + 4)
Learning Outcomes: After the course students will have a comprehensive understanding of fundamental methodological concepts underlying modeling of biological networks and systems. Students will learn to choose appropriate modeling methods for a variety of small- and large-scale problems as well as for different types of experimental data. Students will learn to apply various computational and statistical modeling methods in real interdisciplinary bio-logical problems and have sufficient knowledge to explore the topic further.
Content: Mathematical and statistical models of biological molecular-level networks: gene regulation, epigenetics, signaling, metabolism. Statistical methods for inference of networks from data, and prediction using the models. Mainly probabilistic and machine learning models.
Assessment Methods and Criteria: Examination and exercises/assignment problems.
Study Material: To be specified in MyCourses at the start of the course.
Substitutes for Courses: Replaces former course T-61.5110 Modeling Biological Networks.
Prerequisites: Basic mathematics and statistics courses. Basic bioinformatics courses help.
Evaluation: 0-5
Language of Instruction: English

CS-E5880 Modeling Biological Networks(V) (5-7 sp)

Ansvarig lärare: Harri Lähdesmäki
Kursnivå: Master's level
Undervisningsperiod: II (Autumn)
Arbetsmängd: 24 + 24 (4 + 4)
Lärandemål: After the course students will have a comprehensive understanding of fundamental methodological concepts underlying modeling of biological

networks and systems. Students will learn to choose appropriate modeling methods for a variety of small- and large-scale problems as well as for different types of experimental data. Students will learn to apply various computational and statistical modeling methods in real interdisciplinary bio-logical problems and have sufficient knowledge to explore the topic further.
Innehåll: Mathematical and statistical models of biological molecular-level networks: gene regulation, epigenetics, signaling, metabolism. Statistical methods for inference of networks from data, and prediction using the models. Mainly probabilistic and machine learning models.
Metoder, arbetssätt och bedömningsgrunder: Examination and exercises/assignment problems.
Studiematerial: To be specified in MyCourses at the start of the course.
Ersättande prestationer: Replaces former course T-61.5110 Modeling Biological Networks.
Förkunskaper: Basic mathematics and statistics courses. Basic bioinformatics courses help.
Bedömningsskala: 0-5
Undervisningsspråk: English

CS-E5880 Modeling Biological Networks(V) (5-7 cr)

Responsible teacher: Harri Lähdesmäki
Level of the Course: Master's level
Teaching Period: II (Autumn)
Workload: 24 + 24 (4 + 4)
Learning Outcomes: After the course students will have a comprehensive understanding of fundamental methodological concepts underlying modeling of biological networks and systems. Students will learn to choose appropriate modeling methods for a variety of small- and large-scale problems as well as for different types of experimental data. Students will learn to apply various computational and statistical modeling methods in real interdisciplinary bio-logical problems and have sufficient knowledge to explore the topic further.
Content: Mathematical and statistical models of biological molecular-level networks: gene regulation, epigenetics, signaling, metabolism. Statistical methods for inference of networks from data, and prediction using the models. Mainly probabilistic and machine learning models.
Assessment Methods and Criteria: Examination and exercises/assignment problems.
Study Material: To be specified in MyCourses at the start of the course.
Substitutes for Courses: Replaces former course T-61.5110 Modeling Biological Networks.
Prerequisites: Basic mathematics and statistics courses. Basic bioinformatics courses help.
Grading Scale: 0-5
Language of Instruction: English

CS-E5890 Statistical Genetics and Personalised Medicine (5 cr)

Responsible teacher: Harri Lähdesmäki
Level of the Course: Master's level (but can be included in doctoral studies as well)
Teaching period: IV (Spring)
Workload: 24 + 12 (4 + 2)
Learning Outcomes: After the course students will have a basic understanding of statistical data analysis methods that are used in various genetics, biomedicine, personalized medicine and digital health problems. Students will learn skills to apply various statistical methods in real biomedical problems.
Content: The course introduces statistical methods for analyzing high-throughput biological data in various genetics and personalized medicine problems, including e.g. genetic association analysis, survival analysis, biomarker identification and drug response modeling.
Assessment Methods and Criteria: Exercise work/Project assignments.
Study Material: To be specified in MyCourses at the start of the course.
Substitutes for Courses: Replaces the course T-61.6070 Special Course in Bioinformatics I.
Prerequisites: Basics in mathematics, statistics and computer science.
Evaluation: 0-5, may be graded with pass/fail
Language of Instruction: English

CS-E5890 Statistical Genetics and Personalised Medicine (5 sp)

Ansvarig lärare: Harri Lähdesmäki
Kursnivå: Master's level (but can be included in doctoral studies as well)
Undervisningsperiod: IV (Spring)
Arbetsmängd: 24 + 12 (4 + 2)
Lärandemål: After the course students will have a basic understanding of statistical data analysis methods that are used in various genetics, biomedicine, personalized medicine and digital health problems. Students will learn skills to apply various statistical methods in real biomedical problems.
Innehåll: The course introduces statistical methods for analyzing high-throughput biological data in various genetics and personalized medicine problems, including e.g. genetic association analysis, survival analysis, biomarker identification and drug response modeling.
Metoder, arbetssätt och bedömningsgrunder: Exercise work/Project assignments.
Studiematerial: To be specified in MyCourses at the start of the course.
Ersättande prestationer: Replaces the course T-61.6070 Special Course in Bioinformatics I.
Förkunskaper: Basics in mathematics, statistics and computer science.
Bedömningsskala: 0-5, may be graded with pass/fail
Undervisningsspråk: English

CS-E5890 Statistical Genetics and Personalised Medicine (5 cr)

Responsible teacher: Harri Lähdesmäki
Level of the Course: Master's level (but can be included in doctoral studies as

well)
Teaching Period: IV (Spring)
Workload: 24 + 12 (4 + 2)
Learning Outcomes: After the course students will have a basic understanding of statistical data analysis methods that are used in various genetics, biomedicine, personalized medicine and digital health problems. Students will learn skills to apply various statistical methods in real biomedical problems.
Content: The course introduces statistical methods for analyzing high-throughput biological data in various genetics and personalized medicine problems, including e.g. genetic association analysis, survival analysis, biomarker identification and drug response modeling.
Assessment Methods and Criteria: Exercise work/Project assignments.
Study Material: To be specified in MyCourses at the start of the course.
Substitutes for Courses: Replaces the course T-61.6070 Special Course in Bioinformatics I.
Prerequisites: Basics in mathematics, statistics and computer science.
Grading Scale: 0-5, may be graded with pass/fail
Language of Instruction: English

CS-L4080 Ohjelmistotekniikan tutkimusseminaari(V) (3-10 op)

Vastuuopettaja: Eljas Soisalon-Soininen; Jorma Tarhio; Lauri Malmi
Kurssin taso: Tohtoritaso
Opetusperiodi: Sopimuksen mukaan.
Sisältö: Seminaarin aihe vaihtelee.
Korvaavuudet: CSE-L7200
Arvosteluasteikko: 0-5, voidaan myös arvostella hyväksytty / hylätty.
Opetuskieli: Suomi tai englanti
Lisätietoja: Kurssikoodilla voidaan vuoden aikana järjestää useita seminaareja, joista osa on suomeksi ja osa englanniksi. Kurssi on tarkoitettu jatko- ja maisteriopiskelijoille.

CS-L4080 Forskningsseminar i programteknik(V) (3-10 sp)

Ansvarig lärare: Eljas Soisalon-Soininen; Jorma Tarhio; Lauri Malmi
Kursnivå: Doktornivå
Undervisningsperiod: Enligt avtalet.
Innehåll: Temat för seminariet varierar.
Ersättande prestationer: CSE-L7200
Bedömningsskala: 0-5, kan bedömas godkänt/underkänt.
Undervisningsspråk: Finska eller engelska
Tilläggsinformation: Under läsåret kan ordnas många seminarier med denna kurskod. En del av ordnas på finska och andra på engelska. Kursen är avsedd för fortbildnings- och magisterstuderande.

CS-L4080 Research seminar in software technology(V) (3-10 cr)

Responsible teacher: Eljas Soisalon-Soininen; Jorma Tarhio; Lauri Malmi

Level of the Course: Doctoral level
Teaching Period: According to agreement.
Content: The contents of this seminar vary.
Substitutes for Courses: CSE-L7200
Grading Scale: 0-5, may be graded with pass/fail.
Language of Instruction: Finnish or English
Further Information: Several different seminars may be arranged under this course code during the year. Some of these will be given in English, some in Finnish. The course is for doctoral and master's students.

CS-L4090 Nonequilibrium Statistical Physics(V) (7 cr)

Responsible teacher: Riku Linna; Santo Fortunato
Status of the Course: Master's Programme in Life Science Technologies, optional course of major Complex Systems
Level of the Course: Master's and doctoral level
Teaching period: Course not offered in 2016-17!
Learning Outcomes: After having completed the course the student will have an understanding of the central principles and concepts of non-equilibrium statistical physics. She/he will also be familiar with essential analytical methods used in solving the related problems.
Content: General principles and methods in non-equilibrium statistical physics will be covered in connection with selected important physical models. Diffusion: walks with broad distributions, first-passage properties. Aggregation: master equations, exact solution methods, scaling.
Spin dynamics: the voter model, Ising-Glauber model, Glauber dynamics. Coarsening: conservative and non-conservative dynamics, extremal dynamics. Disorder: disordered spin chain, random walks in random potentials and velocity fields. Population dynamics: continuum formulation, discrete reactions, fluctuations.
Substitutes for Courses: Replaces course BECS-L4072 / BECS-L4071 Nonequilibrium Statistical Physics
Evaluation: 0 - 5
Language of Instruction: English

CS-L4090 Nonequilibrium Statistical Physics(V) (7 sp)

Ansvarig lärare: Riku Linna; Santo Fortunato
Kursens status: Master's Programme in Life Science Technologies, optional course of major Complex Systems
Kursnivå: Master's and doctoral level
Undervisningsperiod: Course not offered in 2016-17!
Lärandemål: After having completed the course the student will have an understanding of the central principles and concepts of non-equilibrium statistical physics. She/he will also be familiar with essential analytical methods used in solving the related problems.
Innehåll: General principles and methods in non-equilibrium statistical physics will be covered in connection with selected important physical models. Diffusion:

walks with broad distributions, first-passage properties. Aggregation: master equations, exact solution methods, scaling.
Spin dynamics: the voter model, Ising-Glauber model, Glauber dynamics. Coarsening: conservative and non-conservative dynamics, extremal dynamics. Disorder: disordered spin chain, random walks in random potentials and velocity fields. Population dynamics: continuum formulation, discrete reactions, fluctuations.
Ersättande prestationer: Replaces course BECS-L4072 / BECS-L4071 Nonequilibrium Statistical Physics
Bedömningsskala: 0 - 5
Undervisningsspråk: English

CS-L4090 Nonequilibrium Statistical Physics(V) (7 cr)

Responsible teacher: Riku Linna; Santo Fortunato
Status of the Course: Master's Programme in Life Science Technologies, optional course of major Complex Systems
Level of the Course: Master's and doctoral level
Teaching Period: Course not offered in 2016-17!
Learning Outcomes: After having completed the course the student will have an understanding of the central principles and concepts of non-equilibrium statistical physics. She/he will also be familiar with essential analytical methods used in solving the related problems.
Content: General principles and methods in non-equilibrium statistical physics will be covered in connection with selected important physical models. Diffusion: walks with broad distributions, first-passage properties. Aggregation: master equations, exact solution methods, scaling.
Spin dynamics: the voter model, Ising-Glauber model, Glauber dynamics. Coarsening: conservative and non-conservative dynamics, extremal dynamics. Disorder: disordered spin chain, random walks in random potentials and velocity fields. Population dynamics: continuum formulation, discrete reactions, fluctuations.
Substitutes for Courses: Replaces course BECS-L4072 / BECS-L4071 Nonequilibrium Statistical Physics
Grading Scale: 0 - 5
Language of Instruction: English