# Catalogue report

**LUT School of Energy Systems**

# Master's Programme in Electrical Engineering

## Master's Programme in Electrical Engineering 2018-2019 (120 ECTS)

### Facts

- Degree Master of Science in Technology (M.Sc. Tech.), (Diplomi-insinööri in Finnish)
- Higher university degree, gives eligibility to apply for scientific doctoral studies
- Extent 120 ECTS credits
- Duration two years, full-time studies of 60 ECTS per academic year.

### Learning Outcomes of the Programme

**After completion of the M.Sc. programme in Electrical Engineering, the graduate**
is able to work independently and scientifically, acquire information and formulate solutions to complex problems and tasks. He/she has an ability to work as a member of team, is able to organise, carry out and lead projects and has the required communication skills. A Master of Science is aware of ethical aspects of the field and its effects on society, and is capable of critically assessing the future prospects of the field. A Master of Science in Electrical Engineering is able to apply the essential theories of electrical engineering to practical electrotechnical and electronics applications. A graduate from the Degree Programme is able to apply his/her knowledge in jobs in product development, research and marketing as well as in management of these. In addition to technical competences, a student may complement his/her professional skills by business studies. For those interested in establishing an enterprise, there is an opportunity to include suitable studies in business in the degree. For students interested in foreign languages and international affairs, the university provides a large array of language studies as well as excellent opportunities for student exchange and training abroad. The Degree Programme also prepares a student for postgraduate and independent studies.

1. Electricity Market
The student completing the specialisation studies in electricity market can explain the basic operating principles of electricity and emissions trading markets and is able to apply these knowledge and skills to operational activities in the electricity market. The student is able to understand the core idea and thinking behind sustainability and its importance in order to limit or decelerate environmental damage. Further, the student acquaints her/himself with the latest research in the field and is able to identify the influence of technical and electricity market development in the electric energy system. Studies for instance in solar economy and minor studies in business and industrial management support the studies in the electricity market.

2. Electrical Drives
The student completing the specialisation studies in electrical drives masters electrical drive system concepts (e.g. frequency converter, electric motor or generator and mechanical load). The student understands vector control methods of rotating electrical machines and is able to design control algorithms or applications software for frequency converters. Further, the student is able to model the operation of different electrical machines and use simulation tools for electromechanical systems and their parts. Additionally, the student is able to dimension and choose appropriate components for an electrical drive. A student specialising in electrical drives is recommended

to take studies for instance in control engineering and embedded systems, mechanical engineering, mechatronics, hydraulics and energy technology. The module contains laboratory assignments in the Laboratory Course in Electrical Power Engineering.

3. Power Electronics
The student completing the specialisation studies in power electronics can produce main circuit solutions for different power electronics applications and their thermal design. Further, the student is able to design electromechanical components, recognise the main loss mechanisms and sources of interference. The student is also able to describe the operating and control principles of converters and rectifiers and switched-mode power supplies. The student is recommended to take studies in control engineering and embedded systems. The module contains laboratory assignments in the Laboratory Course in Electrical Power Engineering.

4. Design of an Electrical Machine
The student completing the specialisation studies in the design of an electrical machine can design and use electrical machines and develop electrical drive system concepts (e.g. frequency converter, electric motor or generator and mechanical load). Further, the student is able to model and simulate electromechanical systems and masters numerical field solution. In addition, the student knows the basics of designing control algorithms or application software for frequency converters. A student specialising in electrical drives and machines is recommended to take studies in mechanical engineering, mechatronics, hydraulics or energy technology. The module contains laboratory assignments in the Laboratory Course in Electrical Power Engineering.

5. Electric Conversion Systems
The student completing the specialisation studies in electric conversion systems knows the essential functional principles, component technology and control principles of power-electronics-based electrical energy conversion systems. The student is able to design a basic system topology, and select and dimension components for different electric conversion system applications. The main fields of application are industrial drives, marine vessel power systems, electric vehicle power systems, smart grid technology, and wind and solar power technology.

6. Solar Economy
The student completing the specialisation studies in solar economy is able to describe renewable energy technologies and recognise issues related to renewable energy production and economics. Moreover, the student is able to describe and explain renewable energy conversion processes and is capable of respective investment and system planning.

7. Control and Automation
The student completing the specialisation studies in control and automation is able to establish requirement specifications for a control application, and implement and test a control system meeting the requirements, also as a part of a larger product development project. Further, the student is able to make a dynamic model for a system and simulate it. He/she is able to design digital control algorithms and digital filtering of a measurement signal. Moreover, the student is acquainted with the equipment and system design of automation and is able to select appropriate components and data transmission solutions for a control system. He/she is able to implement a control system programmatically in an automation device or embedded control electronics.

8. Embedded Systems
The student completing the specialisation studies in embedded systems is able to design and implement embedded systems using the most common programming and description languages. Further, the student has an ability to work as a part of product development project, in which the implementation of equipment or a service is based on the control algorithms of an embedded system, for example, a microcontroller. The emphasis of the studies is on programming of embedded systems and design of digital filters.

9. Microelectronics
The student completing the specialisation studies in microelectronics can describe the structure, operation and physics of semiconductor components. The student is also able to model the operation of integrated circuit components by simulation software. Further, the student is able to describe the microelectronics production phases and methods and apply the latest research information in the field.

## Degree Structure

The Master's degree (120 ECTS) consists of core studies, specialisation studies, minor studies and elective studies. The Master's Thesis and Seminar is included in the specialisation studies.

### Double Degree Programme

**The MSc in Electrical Engineering is also available as a Double Degree Programme for the students of our partner universities.** The Double Degree Programme has a separate degree structure of its own. Depending on her/his choice of specialisation, a student completing the studies of Electrical Engineering is able to

• explain the basic operating principles of electricity markets and is able to apply these knowledge and skills to operational activities in the electricity market
• identify the influence of technical and electricity market development in the electric energy system
• analyze and design power electronics systems
• analyze and design electrical motors and drives
• analyze and design control algorithms for electrical systems
• implement control an signal processing algorithms by embedded programming
• manage simulation software for system dynamics and electromagnetic fields.

See Uni-portal:
Electrical Engineering

# Degree structures

## Degree Structure

The Master's degree (120 ECTS) consists of core studies, specialisation studies, minor studies and elective studies.

The Master's Thesis and Seminar is included in the **specialisation studies**. The student includes two to three elective modules in her/his specialisation studies. Elective modules: Electricity Market, Electrical Drives, Power Electronics, Design of Electrical Machines, Electric Conversion Systems, Solar Economy, Control and Automation, Embedded Systems and Microelectronics. If the total of major studies exceeds 80 cr., no minor subject is required.

The student must take a suitable amount of **elective studies** to reach the total of 120 ECTS required for the Master's degree. The student may include any courses taught at LUT, also another minor, in his/her Master's degree. Studies in other domestic or foreign higher education institutions, the leadership training provided by the National Defence Forces of Finland or a max. of 8 ECTS of internship (BL10A8000 DI-tutkinnon työharjoittelu 2-10 ECTS) can be included in the degree by application; the studies are approved by the Head of degree programme.

The **minor studies** can be selected freely from the minors provided by LUT (check the required prerequisites, if any), or they can be studied in another domestic or foreign university. The study programme in Electrical Engineering provides the minor Electrical Engineering (SaDsähk Sähkötekniikka), where the student chooses one of the elective specialisation modules. If the size of the elective module is less than 20 ECTS, the remaining credits are selected from the courses provided by other specialisation studies. If the total of specialisation studies exceeds 80 ECTS, no minor studies are required.

The MSc in Electrical Engineering is also available as a Double Degree Programme for the students of our partner universities. The Double Degree Programme has a separate degree structure of its own. The double degree students choose either Electrical Machines and Drives, Control Systems or Electricity Market as their specialisation.

See the degree structures for details.

# Master's Programme for Double Degree Students/Electrical Engineering 2018-2019

Degree structure status: accepted

Academic year: 2018-19

Beginning date of the academic year: 01.08.2018

## Specialisation Studies in Electrical Engineering/DD (min 60 cr)

The extent of specialisation studies for double degree students is 60-63 ECTS.
Choose one of the following specialisations:
Electrical Machines and Drives 61 ECTS
Control Systems 63 ECTS
Electricity Market 60 ECTS.

### Specialisation in Control Systems

SaDDCS: Specialisation in Control Systems, 63 cr
*Alternative module 63 ECTS cr.*
BL10A8600: Master's Thesis, 30 cr
BL30A0600: Power Electronics, 6 cr
BL30A1020: Electrical Drives, Compact, 4 cr
BL40A2810: Automation, 6 cr
BL40A1101: Embedded System Programming, 5 cr
BL40A1202: Digital Control Design, 6 cr
BL40A2700: System Engineering Project Work, 6 cr

### Specialisation in Electrical Machines and Drives

SaDDEMaD: Specialisation in Electrical Machines and Drives, 61 cr
*Alternative module 61 ECTS cr*
BL10A8600: Master's Thesis, 30 cr
BL30A0400: Design of an Electrical Machine, 6 cr
BL30A0600: Power Electronics, 6 cr
BL30A1001: Electrical Drives, 8 cr
BL30A1200: Numerical Methods in Electromagnetism, 4 cr
BL40A1101: Embedded System Programming, 5 cr
BL50A0600: Electromagnetic Compatibility in Power Electronics, 2 cr

### Specialisation in Electricity Market

SaDDEM: Specialisation in Electricity Market, 60 cr
*Alternative module 60 ECTS*
A350A0200: Introduction to Economics, 6 cr
BH50A1200: Energy Systems Engineering, 6 cr
BL20A0201: Power Exchange Game for Electricity Markets, 3 cr
BL20A0401: Electricity Market, 5 cr
BL20A1300: Energy Resources, 6 cr
BL40A2910: Electric Energy Conversion Systems, 4 cr
BL10A8600: Master's Thesis, 30 cr

## Credit transfer from studies at home university (max 50 cr)

A max. of 50 ECTS of credit transfer from studies at home university can be added here. The decision on the credit transfers is made by the student's degree programme at LUT. Contact study counselling for detailed instructions.

### Electives

Choose enough courses to attain a min. of 120 ECTS in the M.Sc. degree.
Electives can be any courses offered by LUT if the required prerequisites are fulfilled. Studies in other universities /from abroad or a max. of 10 ECTS of internship (BL10A8000 Work Internship in Master's Degree, 2-10 ECTS) may be included upon application, too.

## Master's Programme in Electrical Engineering 2018-2019

Degree structure status: accepted

Academic year: 2018-19

Beginning date of the academic year: 01.08.2018

### Core Studies (min 18 cr)

The extent of core studies is 18-33 ECTS cr. The extent of obligatory work internship is 2 ECTS cr. The credits exceeding the obligatory amount are included in elective studies.

The student takes 6 ECTS cr. at the minimum of at least one of the laboratory courses. Note that in some modules of the specialisation studies there are requirements concerning the laboratory courses. The modules Electrical Drives, Power Electronics and Design of Electrical Machine contain laboratory assignments in the course Laboratory Course in Electrical Power Engineering.

SaDYdin: , 18 - 36 cr

*Pakolliset ydinopinnot 12-13 op. Ydinopintoihin kuuluu pakollista työharjoittelua 2 op. Obligatory core studies 12-13 ECTS cr. The extent of obligatory work internship in general studies is 2 cr.*

BL10A8000: Work internship in Master's degree, 2 - 10 cr
BL40A2301: Energy Efficiency, 6 cr

*Keskenään vaihtoehtoiset opintojaksot. Alternative to each other.*

BL20A0900: Science, Technology and Society, 4 cr
BL20A0910: Technology and Society, 4 cr

*Vain opiskelijoille, jotka eivät ole suorittaneet kandidaatin opintoja LUT:ssa. Only for the students who have not studied their Bachelor’s studies at LUT.*

BH60A4600: Introduction to M.Sc. Studies, 1 cr

*Laboratorio/työkursseja suoritetaan vähintään 6 op. The student takes 6 cr. at the minimum of at least one of the laboratory courses.*

BL30A1102: Laboratory Course in Electrical Power Engineering, 3 - 8 cr
BL40A0601: Laboratory Course in Control Systems and Signal Processing, 2 - 6 cr
BL50A1600: Electronics, Laboratory Course 2, 3 - 6 cr

### Specialisation Studies in Electrical Engineering (70 - 95 cr)

The specialisation studies in electrical engineering, a min. of 70 ECTS cr., comprise a Master’s thesis (30 ECTS cr.) and two to three elective modules.

SaDEESpec: Specialisation Studies in Electrical Engineering, 70 cr
- *Master's thesis 30 ECTS cr.*
  - BL10A8600: Master's Thesis, 30 cr
- *Elective modules, choose two to three modules to attain a min. of 70 ECTS cr. in the specialisation studies.*
  - SaDEIMa: Electricity Market, 22 - 23 cr
    - *Elective module 22-23 ECTS cr.*
      - BL20A0201: Power Exchange Game for Electricity Markets, 3 cr
      - BL20A1600: Smart Grids, 5 cr
      - BH60A4400: Introduction to Sustainability, 3 cr
      - BH60A5700: Business and Sustainability, 6 cr
    - *Choose Electricity Market, if you have not studied it earlier. Otherwise, choose Investointihankkeiden elinkaarilaskelmat (taught in Finnish only).*
      - BL20A0401: Electricity Market, 5 cr
      - CS31A0610: Life-Cycle Costing of Investment Projects, 6 cr
  - SaDEIDri: Electrical Drives, 25 cr
    - *Elective module 25 ECTS cr.*
      - BL30A0600: Power Electronics, 6 cr
      - BL30A0901: Power Electronic Components, 5 cr
      - BL30A1001: Electrical Drives, 8 cr
      - BL40A2810: Automation, 6 cr
  - SaDPoEI: Power Electronics, 19 cr
    - *Elective module 19 ECTS cr.*
      - BL20A0100: Thermal Design of an Electric Device, 3 cr
      - BL30A0600: Power Electronics, 6 cr
      - BL30A0800: Electromagnetic Components, 3 cr
      - BL30A0901: Power Electronic Components, 5 cr
      - BL50A0600: Electromagnetic Compatibility in Power Electronics, 2 cr
  - SaDDoEm: Design of Electrical Machines, 24 cr
    - *Elective module 24 ECTS cr.*
      - BL20A0100: Thermal Design of an Electric Device, 3 cr
      - BL30A0400: Design of an Electrical Machine, 6 cr
      - BL30A0800: Electromagnetic Components, 3 cr
      - BL30A1001: Electrical Drives, 8 cr
      - BL30A1200: Numerical Methods in Electromagnetism, 4 cr
  - SaDECS: Electric Conversion Systems, 24 cr
    - *Elective module 20 ECTS cr.*
      - BL30A0600: Power Electronics, 6 cr
      - BL30A1020: Electrical Drives, Compact, 4 cr
      - BL40A2401: Electrical Engineering in Wind and Solar Systems, 6 cr
      - BL40A2910: Electric Energy Conversion Systems, 4 cr
  - SaDSoEc: Solar Economy, 18 - 21 cr
    - *Elective module 18-21 ECTS cr.*
      - BL20A1300: Energy Resources, 6 cr
      - BL20A1400: Renewable Energy Technology, 6 cr
      - BL20A1500: Energy Scenarios, 6 cr
    - *LUT Summer School course, optional.*
      - BL10A8400SS: Solar Economy and Smart Grids, 3 cr
  - SaDCaA: Control and Automation, 22 cr
    - *Elective module 22 ECTS cr.*
      - BL40A0810: Digital Signal Processing II, 4 cr
      - BL40A1202: Digital Control Design, 6 cr
      - BL40A2700: System Engineering Project Work, 6 cr
      - BL40A2810: Automation, 6 cr
  - SaDEmSy: Embedded Systems, 24 cr
    - *Elective module 24 ECTS cr.*
      - BL40A0810: Digital Signal Processing II, 4 cr
      - BL40A1101: Embedded System Programming, 5 cr
      - BL40A1601: Embedded System Design, 6 cr
      - BL40A1740: Digital Electronics, 3 cr

BL40A2700: System Engineering Project Work, 6 cr
SaDMI: Microelectronics, 20 cr
*Elective module 20 ECTS cr.*
BL50A1300: Advanced Course in Electronics, 6 cr
BM30A1600: Microelectronics, 6 cr
BM30A1701: Physics of Semiconductor Devices, 6 cr
BM30A2100: Microelectronics Processing Technology, 2 cr

### Minor Studies (min 20 cr)

The minor studies can be selected freely from the minors provided by LUT, or they can be studied in another domestic or foreign university (by application). The study programme in Electrical Engineering provides the minor Electrical Engineering (SaDSähk Sähkötekniikka), where the student chooses one of the elective specialisation modules. If the size of the elective module is less than 20 ECTS cr., the remaining credits are selected from the courses provided by other specialisation studies.

These minors are offered in English in the academic year 2018-2019:
EnDSaBT Bio-Energy Technology
EnDMES Modelling of Energy Systems
KeSOD400 Biobased Chemical Engineering
KeSOD500 Advanced Chemistry
KoDSaMate Advanced Materials Engineering
KoDSaManu Modern Manufacturing
YmDSaResp Environmental Responsibility
MaDIntM300 Technomathematics
FyDInt300 Technical Physics
MaDSaCompu Computer Vision and Pattern Recognition
TiDSOsedt Software Engineering and Digital Transformation minor
TuSOEntr Entrepreneurship, minor
KaSOIbm International Business and Management.

If the total of specialisation studies exceeds 80 cr., no minor studies are required.

### Elective Studies

The student must take a suitable amount of elective studies to reach the total of 120 ECTS cr. required for the Master’s degree. The student may include any courses taught at LUT in his/her Master's degree. Studies in other domestic or foreign higher education institutions, the leadership training provided by the National Defence Forces or internship (BL10A8000 Work Internship in Master's Degree, a max. of 8 ECTS cr.) can be included in the degree by application; the studies are approved by the Head of Degree Programme.

## Courses and study modules not included in degree structures

The minor studies can be selected freely from the minors provided by LUT (check the required prerequisites, if any), or they can be studied in another domestic or foreign university. The study programme in Electrical Engineering provides the minor Electrical Engineering (SaDsähk Sähkötekniikka), where the student chooses one of the elective specialisation modules. If the size of the elective module is less than 20 ECTS, the remaining credits are selected from the courses provided by other specialisation studies. If the total of specialisation studies exceeds 80 ECTS, no minor studies are required.

**The minors taught in English at LUT in the academic year 2018-2019 are:**

SaDSähk Sähkötekniikka/Electrical Engineering (one of the modules which is not included in thespecialisation studies)
EnDSaBT Bio-Energy Technology
EnDMES Modelling of Energy Systems
KeSOD400 Biobased Chemical Engineering
KeSOD500 Advanced Chemistry
KoDSaMate Advanced Materials Engineering
KoDSaManu Modern Manufacturing
YmDSaResp Environmental Responsibility
MaDIntM300 Technomathematics
FyDInt300 Technical Physics
MaDSaCompu Computer Vision and Pattern Recognition
TiDSOsedt Software Engineering and Digital Transformation minor
TuSOEntr Entrepreneurship, minor
KaSOIbm International Business and Management.

KeSoD500: Advanced Chemistry, 20 - 25 cr
*Choose a min. of 20 ECTS*
BJ02A1012: Concepts of Analytical and Inorganic Chemistry, 5 cr
BJ02A1600: Biobased Materials and Advanced Organic Chemistry, 5 cr
BJ02A1031: Solution Chemistry, 5 cr
BJ02A4070: Principles of Thermal Gas-Liquid Processes, 5 cr
BJ03A1040: Advanced Materials in Adsorption and Ion Exchange, 5 cr
KoDSaMate: Advanced Materials Engineering, 20 - 30 cr
*Obligatory Studies 25 ECTS cr*
BK90C1900: Introduction to Materials Engineering, 4 cr
BK90C2000: Hybrid Materials, 3 cr
BK90C2100: Functional Properties of Nanomaterials, 3 cr
BK90C2200: Sustainable Manufacturing of Advanced Materials, 5 cr
BK90C2300: High Performance Products, 5 cr
BK90C2400: Project course in Material Engineering, 5 cr
EnDSaBT: Bio-Energy Technology, 21 - 22 cr
*Obligatory studies of 13 ECTS.*
BH50A1300: Maintenance Management, 4 cr
BH50A1500: Bioenergy Technology Solutions, 6 cr
BH61A0600: Bioenergy, 3 cr
*List of selectable courses, choose enough courses to attain a min. of 23 ECTS. Either BH50A1200 or BH50A1400 must be included in this minor.*
BH30A0701: Reliability Engineering, 4 cr
BH40A1600: Turbomachinery in Renewable Energy, 5 cr
BL20A0401: Electricity Market, 5 cr
BH50A1200: Energy Systems Engineering, 6 cr
BH50A1400: Steam Boilers, 6 cr
KeSoD400: Biobased Chemical Engineering, 20 - 30 cr
*Choose a min. of 20 ECTS. This minor is suitable for distance learning.*
BJ02A1090: Environmental and Industrial Analytics, 5 cr
BJ02A1100: Biorefineries, 5 cr
BJ02A1200: Bioeconomy, 5 cr
BJ02A1500: Current Issues in Enabling Technologies for Circular Economy, 5 cr
BJ02A1600: Biobased Materials and Advanced Organic Chemistry, 5 cr
BJ02A4070: Principles of Thermal Gas-Liquid Processes, 5 cr
MaDSaCompu: Computer Vision and Pattern Recognition, 20 - 30 cr
*Obligatory Studies 12 ECTS cr*
BM40A0701: Pattern Recognition, 6 cr
BM40A1201: Digital Imaging and Image Preprocessing, 6 cr
*Choose enough courses to attain at least 20 ECTS cr together with obligatory courses*

BM10A1100: Advanced Methods in Mathematics, Computing and Physics, 3 - 6 cr
BM20A3001: Statistical Analysis in Modelling, 5 cr
BM20A3401: Design of Experiments, 4 cr
BM20A5001: Principles of Technical Computing, 4 cr
BM20A6200: Inverse Problems and Normed Spaces, 6 cr
BM40A0801: Machine Vision and Digital Image Analysis, 6 cr
BM40A0901: Computer Vision, 6 cr
BM40A1400: GPGPU Computing, 6 cr
CS38A0060: Fuzzy sets and fuzzy logic, 6 cr
CS38A0070: Fuzzy data analysis, 6 cr

SaDsähk: Electrical Engineering, 20 cr

*Valitse sivuopintokokonaisuuteen yksi moduuli ja täydennä sitä tarvittaessa 20 op laajuuteen muiden moduulien opintojaksoilla. Choose one of the elective specialisation modules. If the size of the elective module is less than 20 cr., the remaining credits are selected from the other modules.*

SaDsä: Sähköverkot, 23 - 28 cr

*Valinnainen moduuli 23 op*

BL20A1600: Smart Grids, 5 cr
BL20A0500: Electricity Distribution Technology, 8 cr
BL20A0600: Electrical Power Transmission, 5 cr
BL20A1001: Protection of Electricity Networks, 5 cr

SaDEK: Elektroniikan komponentit, 21 - 24 cr

*Obligatory*

BL50A1300: Advanced Course in Electronics, 6 cr
BL50A1400: Analog Electronics, 6 cr
BL50A1600: Electronics, Laboratory Course 2, 3 - 6 cr
BM30A0601: Optoelectronics, 6 cr

SaDET: Elektroniikan tuotesuunnittelu, 17 - 24 cr

*Obligatory*

BL20A0100: Thermal Design of an Electric Device, 3 cr
BL50A0802: Electronic Equipment and Systems Design, 7 cr
BL50A0900: Analog Signal Processing, 6 cr
BL50A1700: Electronics project, 2 - 8 cr

SaDMI: Microelectronics, 20 cr

*Elective module 20 ECTS cr.*

BL50A1300: Advanced Course in Electronics, 6 cr
BM30A1600: Microelectronics, 6 cr
BM30A1701: Physics of Semiconductor Devices, 6 cr
BM30A2100: Microelectronics Processing Technology, 2 cr

SaDEIMa: Electricity Market, 22 - 23 cr

*Elective module 22-23 ECTS cr.*

BL20A0201: Power Exchange Game for Electricity Markets, 3 cr
BL20A1600: Smart Grids, 5 cr
BH60A4400: Introduction to Sustainability, 3 cr
BH60A5700: Business and Sustainability, 6 cr

*Choose Electricity Market, if you have not studied it earlier. Otherwise, choose Investointihankkeiden elinkaarilaskelmat (taught in Finnish only).*

BL20A0401: Electricity Market, 5 cr
CS31A0610: Life-Cycle Costing of Investment Projects, 6 cr

SaDEIDri: Electrical Drives, 25 cr

*Elective module 25 ECTS cr.*

BL30A0600: Power Electronics, 6 cr
BL30A0901: Power Electronic Components, 5 cr
BL30A1001: Electrical Drives, 8 cr
BL40A2810: Automation, 6 cr

SaDPoEI: Power Electronics, 19 cr

*Elective module 19 ECTS cr.*

BL20A0100: Thermal Design of an Electric Device, 3 cr
BL30A0600: Power Electronics, 6 cr
BL30A0800: Electromagnetic Components, 3 cr

BL30A0901: Power Electronic Components, 5 cr
BL50A0600: Electromagnetic Compatibility in Power Electronics, 2 cr
SaDDoEm: Design of Electrical Machines, 24 cr
*Elective module 24 ECTS cr.*
BL20A0100: Thermal Design of an Electric Device, 3 cr
BL30A0400: Design of an Electrical Machine, 6 cr
BL30A0800: Electromagnetic Components, 3 cr
BL30A1001: Electrical Drives, 8 cr
BL30A1200: Numerical Methods in Electromagnetism, 4 cr
SaDECS: Electric Conversion Systems, 24 cr
*Elective module 20 ECTS cr.*
BL30A0600: Power Electronics, 6 cr
BL30A1020: Electrical Drives, Compact, 4 cr
BL40A2401: Electrical Engineering in Wind and Solar Systems, 6 cr
BL40A2910: Electric Energy Conversion Systems, 4 cr
SaDSoEc: Solar Economy, 18 - 21 cr
*Elective module 18-21 ECTS cr.*
BL20A1300: Energy Resources, 6 cr
BL20A1400: Renewable Energy Technology, 6 cr
BL20A1500: Energy Scenarios, 6 cr
*LUT Summer School course, optional.*
BL10A8400SS: Solar Economy and Smart Grids, 3 cr
SaDCaA: Control and Automation, 22 cr
*Elective module 22 ECTS cr.*
BL40A0810: Digital Signal Processing II, 4 cr
BL40A1202: Digital Control Design, 6 cr
BL40A2700: System Engineering Project Work, 6 cr
BL40A2810: Automation, 6 cr
SaDEmSy: Embedded Systems, 24 cr
*Elective module 24 ECTS cr.*
BL40A0810: Digital Signal Processing II, 4 cr
BL40A1101: Embedded System Programming, 5 cr
BL40A1601: Embedded System Design, 6 cr
BL40A1740: Digital Electronics, 3 cr
BL40A2700: System Engineering Project Work, 6 cr
TuSOEntr: Entrepreneurship, minor, 20 - 35 cr
*Obligatory course 6 cr*
CS34A0302: Entrepreneurship Theory, 6 cr
*Elective studies*
CS30A1372: Creative Design and Problem Solving, 6 cr
CS30A1691: Social Sustainability, 6 cr
CS34A0352: Leading business growth, 6 cr
CS34A0401: Strategic Entrepreneurship in an Age of Uncertainty, 6 cr
CS34A0551: Business Idea Development, 6 cr
CS34A0712: Business Governance and Entrepreneurial Renewal, 6 cr
CS34A0721: Entrepreneurship, ownership and family firms, 6 cr
CS34A0733: New Venture Creation, 6 cr
YmDSaResp: Environmental Responsibility, 20 - 30 cr
*Obligatory Studies 23 ECTS cr*
BH60A0252: Solid Waste Management Technology, 7 cr
BH60A2401: Energy Recovery from Solid Waste, 4 cr
BH60A2701: Energy Efficient Environment, 6 cr
BH60A5700: Business and Sustainability, 6 cr
KaSOIbm: International Business and Management, 21 - 35 cr
*Elective courses 21-24 cr*
A370A0401: Case-Course of Business, 6 cr
A380A0000: Cross-Cultural Issues in International Business, 6 cr
A380A0131: Business Relationships in International Value Networks, 6 cr
A380A0201: Sales and Marketing Communication, 6 cr

A380A6050: Introduction to International Business and Planning, 3 cr
CS10A0262: International Business Essentials, 6 cr

EnDMES: Modelling of Energy Systems, 21 cr
*Selectable courses, choose a min. of 20 ECTS*
BH70A0101: Advanced Modelling Tools for Transport Phenomena, 5 cr
BH70A0200: Advanced Topics in Modelling of Energy Systems, 6 cr
BH40A1501: Turbulence Models, 4 cr
BH30A2001: Computational Nuclear Thermal Hydraulics, 3 cr
BH30A2200: Experimental Nuclear Thermal Hydraulics, 3 cr
BH40A1560: Fundamentals of Computational Fluid Dynamics, 6 cr
BH40A1570: Advanced Computational Fluid Dynamics, 5 cr

KoDSaManu: Modern Manufacturing, 20 - 30 cr
*Obligatory Studies 25 ECTS cr*
BK50A4000: Production Processes in Modern Job Shops, 5 cr
BK50A4100: Manufacturing Systems and Scheduling, 5 cr
BK50A4200: Product Flow in Job Shops, 5 cr
BK50A4300: Managing Job Shops, 5 cr
BK50A4401: Fabrication Laboratory, 5 - 10 cr

TiDSOsedt: Software Engineering and Digital Transformation minor, 24 - 30 cr
*Obligatory courses 12 cr*
CT60A5500: Quality Assurance in Software Development, 6 cr
CT70A2000: Requirements Engineering, 6 cr
*Elective courses, choose 12 cr*
CT30A8922: User Experience Design, 6 cr
CT60A5103: Software Engineering Models and Modeling, 6 cr
CT60A5400: Fundamentals of Game Development, 6 cr
CT60A7322: Software Business Development, 3 cr
CT70A4000: Business Process Modelling, 6 cr
CT70A5000: Impact and Benefits of Digitalization, 6 cr
CT70A7000: Digital Business Platforms, 6 cr

FyDInt300: Technical Physics, 20 - 26 cr
*A minimum of 20 ECTS cr should be selected from the courses below.*
BM30A0500: Applied Optics, 6 cr
BM30A1500: Advanced Topics in Material Science, 6 cr
BM30A1600: Microelectronics, 6 cr
BM30A1701: Physics of Semiconductor Devices, 6 cr
BM30A2100: Microelectronics Processing Technology, 2 cr
BM30A2200: Semiconductor and Superconductor Physics, 6 cr
BM30A2500: Nanophysics, 6 cr

MaDIntM300: Technomathematics, 20 cr
*Choose a minimum of 20 ECTS cr*
BM10A1100: Advanced Methods in Mathematics, Computing and Physics, 3 - 6 cr
BM20A3401: Design of Experiments, 4 cr
BM20A5001: Principles of Technical Computing, 4 cr
BM20A5100: Scientific Computing and Numerics for PDEs, 6 cr
BM20A6200: Inverse Problems and Normed Spaces, 6 cr
BM20A6500: Simulation and System Dynamics, 6 cr
CS38A0060: Fuzzy sets and fuzzy logic, 6 cr
CS38A0070: Fuzzy data analysis, 6 cr

# Course descriptions

## Descriptions of courses and study modules included in the degree structures

## SaDDCS: Specialisation in Control Systems, 63 cr

**Validity:** 01.08.2017 -
**Form of study:**
**Type:** Study module
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F

No course descriptions.

*Alternative module 63 ECTS cr.*

### BL10A8600: Master's Thesis, 30 cr

**Validity:** 01.08.2015 -
**Form of study:** Basic studies
**Type:** Master's Thesis
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Katja Hynynen

**Note:**

In Master’s programmes taught in English, the Master’s thesis is always prepared in English.

**Year:**

M.Sc. (Tech.) 2

**Period:**

1-4

**Teaching Language:**

English

**Teacher(s) in Charge:**

Post-doctoral researcher, D.Sc. (Tech.) Katja Hynynen

**Aims:**

Upon completion of the course the student will be able to: 1. delineate a research problem, 2. select research methodology suitable for the study, 3. find relevant reference material and assess the credibility of sources, 4. apply the material correctly to his/her own work, 5. write
a scientific report according to scientific practices with a special reference to electrical engineering.

**Contents:**

Fundamentals of scientific work. Good scientific conduct associated with definition of a research problem, selection of research methodology, problem solving and scientific reporting with special focus on electrical engineering practices. Application of scientific knowledge to problem solving. Good information processing skills. Scientific reporting. Information search. Scientific writing skills. Writing the M.Sc. thesis.

**Teaching Methods:**

M.Sc. thesis, 780 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, M.Sc. thesis 100 %.

**Course Materials:**

Course material in Moodle. Master's thesis instructions in Uni portal.

**Prerequisites:**

B.Sc. (Tech.) degree (not required for students admitted directly into a Master's programme).

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

No

### BL30A0600: Power Electronics, 6 cr

**Validity:** 01.08.2007 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Lasse Laurila

**Note:**

The course is suitable for distance learning.
Course has examination in Examination schedule, but it is not traditional paper exam. The exam will be done with computer.

**Year:**

M.Sc. (Tech.) 1

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Associate professor, D.Sc. (Tech.) Lasse Laurila

**Aims:**

Upon completion of the course the student will be able to: 1. demonstrate good general knowledge of the different basic main circuits in modern power electronics, 2. describe the features and functions of different rectifiers, switch-mode converters and inverters, 3. calculate and simulate typical design tasks of the aforementioned circuits, 4. describe the joint operation of static converters and loads as well as the network interferences caused by converters and alternatives to reduce these interferences.

**Contents:**

Operation of the main circuits of different power converters: rectifiers (single and three-phase), DC-DC switch mode converters and power supplies (buck, boost, buck-boost, flyback, forward), inverters (single and three-phase), resonance converters (ZVS, ZCS). Characteristics and operation. Pulse width modulation (PWM). Harmonic components. Simulation of power electronic circuits (simulation tools used: PSpice and Matlab/Simulink, calculations on Mathcad, Excel). Possible extra assignments to gather extra points to the exam.

**Teaching Methods:**

Combined lectures and tutorials, 28 h, 1st period. Combined lectures and tutorials, 28 h, 2nd period. Moodle-examination, 3 h. Independent study 97 h. The course is suitable for distance learning. Total workload 156 h.

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

Yes

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, examination 100 %. 75 % of tutorial tasks passed or 75 % active presence in tutorials. Possible extra assignments to gather extra points to the exam.

**Course Materials:**

Mohan, Undeland, Robbins: Power Electronics, converters, applications, and design. Chapters 1 to 18. Course material in Moodle.

**Prerequisites:**

Recommended: BL30A0000 Electric Circuits. Integration and derivation (esp. sine and cosine functions). FFT. Laplace transforms. Basic software skills with Excel, Word.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

max 5

### BL30A1020: Electrical Drives, Compact, 4 cr

**Validity:** 01.08.2017 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Juha Pyrhönen

**Note:**

The course has common lectures exercises and homework with the first part of the course BL30A1001 Electrical Drives.
The student may participate either in “Electrical Drives, Compact” or “Electrical Drives”, not in both of them.

**Year:**

M.Sc. (Tech.) 1

**Period:**

2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, D.Sc. (Tech.) Juha Pyrhönen

**Aims:**

Upon completion of the course the student will be able to: 1. understand the role of electrical drives, 2. understand different torque producing principles in different machines, 3. model and simulate a DC motor drive, 4. describe the principles of scalar, vector and direct torque control of rotating field machines, 5. define the most important power electronic converters, 6. discuss the principles of PWM, space vector modulation and DTC. 7. model the behaviour of permanent magnet synchronous machine by using vector equivalent circuits and vector diagrams.

**Contents:**

Theory of electric motor drives, operation and vector equivalent circuits. Torque production in different machines. Power electronic converters suitable for motor and generator drives. Scalar control, vector control, direct flux linkage control and direct torque control (DTC). Permanent magnet synchronous machine drives.

**Teaching Methods:**

Common lectures 24 h, tutorials 24 h, 2nd period. Independent study including homework 56 h. Total workload 104 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

Pass/fail. The course can be passed with via good enough independent homework.

**Course Materials:**

Lecture material in Moodle
The course is based on chapters 1-7 and 9 of the book: Pyrhönen, Hrabovcova, Semken, “Electrical Machine Drives Control: An Introduction”, published by John Wiley et Sons 2016

**Prerequisites:**

The students are recommended to have completed the courses BL30A0000 Electric Circuits, BL10A0100 Basics of Electric Engineering, BL30A0200 Laboratory Course in Electrical Engineering, BL30A0500 Introduction to Electrical Drives and BL30A0800 Electromagnetic Components and to have attended the course BL30A0400 Design of an Electrical Machine.

**Places for exchange-students? (Yes, number/No):**

15–

**Places for Open University Students?(Yes, number/No):**

max 5

### BL40A2810: Automation, 6 cr

**Validity:** 01.08.2017 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Tuomo Lindh, Jan-Henri Montonen

**Year:**

M.Sc. (Tech.) 1

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Associate professor, D.Sc. (Tech.) Tuomo Lindh

**Aims:**

Upon completion of the course the student will be able to: 1. apply automation and digital control theory to practical implementations, 2. use the analog and digital communication techniques applied to automation, 3. apply fieldbuses, 4. formulate a dynamic system model
of motor drives 5. Simulate servo motor driven mechatronic systems, 6. construct controllers and models of dynamic systems using IEC61131-3 and C programming languages, 7. select a proper controller structure, 8. work in a group solving automation and control problems.

**Contents:**

IEC61131-3 programming languages, Feedback devices, Automation hardware and software. Fieldbuses. Basics of servo drive dynamics, Utilizing Simulink models in PLC systems. C/C++ languages in PLC systems. HMI, OPC, IoT in automation. Introduction to safety in automation.

**Teaching Methods:**

Lectures 14 h, exercises 14 h, 1st period.
Lectures 14 h, exercises 14 h, 2nd period.
Independent study: project work 35 h, laboratory exercises 21h
preparation for examination 40 h, examination at Moodle 4 h.
Total workload 156 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

Yes

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, examination 40 %. Project work 60%.

**Course Materials:**

Presentation slides at Moodle.
Karl-Heinz John, Michael Tiegelkamp.IEC 61131-3: Programming Industrial Automation Systems.e-ISBN 978-3-642-12015-2.

**Prerequisites:**

Basics of programming.

**Places for exchange-students? (Yes, number/No):**

Yes, 10.

**Places for Open University Students?(Yes, number/No):**

This course has 1-10 places for open university students. More information on the web site for open university instructions.

### BL40A1101: Embedded System Programming, 5 cr

**Validity:** 01.08.2017 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Jouni Vuojolainen, Tuomo Lindh, Teemu Sillanpää

**Year:**

M.Sc. (Tech.) 1

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Associate professor, D.Sc. (Tech.) Tuomo Lindh

**Aims:**

Upon completion of the course the student will be able to: 1. apply C language and its structures to embedded system programming, 2. form complex data types such as structures, unions and buffers and use these in order to maintain information of different entities (e.g.
processing units), 3. control the registers of a micro controller using C-language, 4. use different PUs of a micro controller, 5. Take into use a real time operation system.

**Contents:**

Design tools, C-language in embedded system programming, utilization of a micro controller environment (registers, timers, buses, A/D conversion etc.). Typical data structures, typical program structures in real-time applications.

**Teaching Methods:**

14 h of lectures, 14 h of tutorials, 1st period. 14 h of lectures, 14 h of tutorials, 2nd period. Assignment. Written examination.
Total workload 130 h.

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, assignment 1 50 %, examination 50 %.

**Course Materials:**

Wolf, W.: Computers as components: principles of embedded computing system design.
Lecture notes.

**Prerequisites:**

Basics of C language.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

This course has 1-5 places for open university students. More information on the web site for open university instructions.

### BL40A1202: Digital Control Design, 6 cr

**Validity:** 01.08.2017 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Olli Pyrhönen, Pasi Peltoniemi, Rafal Jastrzebski

**Year:**

M.Sc. (Tech.) 1

**Period:**

1-2

**Teaching Language:**

Finnish and English

**Teacher(s) in Charge:**

Professor Olli Pyrhönen

**Aims:**

Upon completion of the course students are able to design and implement a digital control system for industrial application independently. The necessary skills are dynamic plant modeling, system design, control synthesis, system simulation and digital controller implementation in an industrial control platform.

**Contents:**

The teaching approach on this course is practical control design and implementation for different applications. The first half of the course introduces design of advanced control methods for different application. The application topics may change yearly. The following topics are included, plant modelling, different state-space and transfer functions algorithms for SISO and MIMO systems, digital controller synthesis, system simulation, controller programming and testing. In the second half of the course every student will design, program and test a controller using an industrial controller platform and a laboratory equipments.

**Teaching Methods:**

28 h interactive lectures in computer class room, 1. period, 14 h control system development project tutorial lectures in computer class room, laboratory working 6 h, exam 3 h, independent studies. Total workload 156 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

Yes

**Examination in Exam (Yes/No):**

No

**Assessment:**

Examination 60%, control system design project 40%.

**Course Materials:**

Lecture script and handout, more detailed material in the text books:
Franklin G.F., Powell J.D., Workman M.L., Digital Control of Dynamic Systems, Addison-Wesley, 1998,
Kuo B., Digital Control Systems, 2nd ed., Oxford University Press, 1992,
Åström K.J., Wittenmark B., Computer Controlled Systems, 3rd ed., Prentice Hall, 1997, 557 p.

**Prerequisites:**

BL40A0200 Säätötekniikan perusteet A or BL40A0300 - Säätötekniikan perusteet B
BL40A0501 - Digitaalisäädön perusteet

**Places for exchange-students? (Yes, number/No):**

max 10

**Places for Open University Students?(Yes, number/No):**

No

### BL40A2700: System Engineering Project Work, 6 cr

**Validity:** 01.08.2013 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Olli Pyrhönen, Jero Ahola, Jan-Henri Montonen, Tuomo Lindh

**Year:**

M.Sc. (Tech.) 2

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Associate professor. D.Sc. (Tech.) Tuomo Lindh, professor, D.Sc. (Tech.) Olli Pyrhönen, professor, D.Sc. (Tech.) Jero Ahola

**Aims:**

Upon completion of the course the student is prepared to work in a R&D team as a system engineer. The student is able to manage the project scheduling and project roles, and share responibilities among group members. The student can produce a tecnical documentation.

**Contents:**

The students will analyse and design a selected electrical energy conversion system in the field of industrial electrical drives, renewable energy conversion or motion control system. The topics are linked to an on-going research project or industrial co-operation in the above-mentioned fields. The project work includes several partly alternative system engineering tasks, such as project planning, preliminary system design, dynamic modelling and simulation, component dimensioning, electrical dimensioning, control design, automation design, control software design and project documentation. The tasks are project dependent and will be defined in the project plan.
Introduction to a system engineering approach in technical projects. Project documentation, different tasks in project work, project planning and implementation, example projects, execution of system engineering tasks, project documentation and presentation. The main result of the project work is technical project documentation including an overall description and the results of agreed system engineering tasks.

**Teaching Methods:**

Introductory lecture, independent group working (3-5 students in one group), individual tasks within the group work, project group meetings with supervisors, writing project documentation, project presentation and demonstration. The project work topics will be defined in detail at the beginning of the course.
Total workload 156 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, Project work that includes management of the project, system design, problem solving, designs, documentation and presentation.
Also the project phases from setting the goals to the design, implementation and utilization are graded.

**Course Materials:**

Project related material.
Jürg Kuster, Eugen Huber, Robert Lippmann, Alphons Schmid, Emil Schneider, Urs Witschi,Roger Wüst. Project Management Handbook, ISBN 978-3-662-45373-5.

**Prerequisites:**

A majority of the M.Sc. (El. Eng.) studies should be completed before participation.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

This course has 1-5 places for open university students. More information on the web site for open university instructions.

## SaDDEMaD: Specialisation in Electrical Machines and Drives, 61 cr

**Validity:** 01.08.2017 -
**Form of study:**
**Type:** Study module
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F

No course descriptions.

*Alternative module 61 ECTS cr*

### BL10A8600: Master's Thesis, 30 cr

**Validity:** 01.08.2015 -
**Form of study:** Basic studies
**Type:** Master's Thesis
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Katja Hynynen

**Note:**

In Master’s programmes taught in English, the Master’s thesis is always prepared in English.

**Year:**

M.Sc. (Tech.) 2

**Period:**

1-4

**Teaching Language:**

English

**Teacher(s) in Charge:**

Post-doctoral researcher, D.Sc. (Tech.) Katja Hynynen

**Aims:**

Upon completion of the course the student will be able to: 1. delineate a research problem, 2. select research methodology suitable for the study, 3. find relevant reference material and assess the credibility of sources, 4. apply the material correctly to his/her own work, 5. write
a scientific report according to scientific practices with a special reference to electrical engineering.

**Contents:**

Fundamentals of scientific work. Good scientific conduct associated with definition of a research problem, selection of research methodology, problem solving and scientific reporting with special focus on electrical engineering practices. Application of scientific knowledge to problem solving. Good information processing skills. Scientific reporting. Information search. Scientific writing skills. Writing the M.Sc. thesis.

**Teaching Methods:**

M.Sc. thesis, 780 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, M.Sc. thesis 100 %.

**Course Materials:**

Course material in Moodle. Master's thesis instructions in Uni portal.

**Prerequisites:**

B.Sc. (Tech.) degree (not required for students admitted directly into a Master's programme).

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

No

### BL30A0400: Design of an Electrical Machine, 6 cr

**Validity:** 01.08.2007 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Juha Pyrhönen

**Year:**

M.Sc. (Tech.) 1

**Period:**

1

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, D.Sc. (Tech.) Juha Pyrhönen

**Aims:**

Upon completion of the course the student will be able to: 1. perform a basic design of a rotating electrical machine, 2. design the simplest winding arrangements and other components of the machine, 3. explain the torque production process in electrical machines, 4. calculate the main data (equivalent circuit parameters) of an electrical machine from machine geometric and winding designs, 5. List and apply the most important materials used in magnetic circuits and windings, 6. model the machine with an equivalent circuit, 7. compare machine designs with each other by using the per unit presentation of machines, 8. use phasor diagrams in the machine analysis, 9. discuss the problems of insulation systems and heat transfer.

**Contents:**

Electromagnetic principles used in machine design, the magnetic circuit of an electric machine, the windings of an electric machine, impacts of the structure of the electric motor on the motor characteristics, calculation of the parameters of an equivalent circuit from the dimensions of the machine (resistances, inductances), effective-value phasor diagrams for different machine types, principles of electric machine design, insulation materials and systems heat transfer.

**Teaching Methods:**

Lectures 24 h, tutorials 24 h, design assignment of an electric machine 48 h and other independent studies 57 h, exam 3 h 1st period.
Total workload 156 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, written examination 100 %. Satisfactorily completed assignment required.
Or: The course can be passed with the grade “Accepted” by satisfactory completion of the homework and the design assignment.

**Course Materials:**

Lecture materials in Moodle.
The course is based on suitable parts of Pyrhönen, Jokinen, Hrabovcova: Design of Rotating Electrical Machines

**Prerequisites:**

Students are recommended to have good knowledge in electromagnetism, completed BL30A0000 Electric Circuits, BL10A0100 Basics of Electric Engineering.

**Places for exchange-students? (Yes, number/No):**

15–

**Places for Open University Students?(Yes, number/No):**

max 5

### BL30A0600: Power Electronics, 6 cr

**Validity:** 01.08.2007 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Lasse Laurila

**Note:**

The course is suitable for distance learning.
Course has examination in Examination schedule, but it is not traditional paper exam. The exam will be done with computer.

**Year:**

M.Sc. (Tech.) 1

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Associate professor, D.Sc. (Tech.) Lasse Laurila

**Aims:**

Upon completion of the course the student will be able to: 1. demonstrate good general knowledge of the different basic main circuits in modern power electronics, 2. describe the features and functions of different rectifiers, switch-mode converters and inverters, 3. calculate and simulate typical design tasks of the aforementioned circuits, 4. describe the joint operation of static converters and loads as well as the network interferences caused by converters and alternatives to reduce these interferences.

**Contents:**

Operation of the main circuits of different power converters: rectifiers (single and three-phase), DC-DC switch mode converters and power supplies (buck, boost, buck-boost, flyback, forward), inverters (single and three-phase), resonance converters (ZVS, ZCS). Characteristics and operation. Pulse width modulation (PWM). Harmonic components. Simulation of power electronic circuits (simulation tools used: PSpice and Matlab/Simulink, calculations on Mathcad, Excel). Possible extra assignments to gather extra points to the exam.

**Teaching Methods:**

Combined lectures and tutorials, 28 h, 1st period. Combined lectures and tutorials, 28 h, 2nd period. Moodle-examination, 3 h. Independent study 97 h. The course is suitable for distance learning. Total workload 156 h.

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

Yes

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, examination 100 %. 75 % of tutorial tasks passed or 75 % active presence in tutorials. Possible extra assignments to gather extra points to the exam.

**Course Materials:**

Mohan, Undeland, Robbins: Power Electronics, converters, applications, and design. Chapters 1 to 18. Course material in Moodle.

**Prerequisites:**

Recommended: BL30A0000 Electric Circuits. Integration and derivation (esp. sine and cosine functions). FFT. Laplace transforms. Basic software skills with Excel, Word.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

max 5

**BL30A1001: Electrical Drives, 8 cr**

**Validity:** 01.08.2010 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Juha Pyrhönen

**Note:**

The first part (2nd period) will be studied in collaboration with BL30A1020 Electrical Drives, Compact. Common lectures, exercises and homework. The student may participate either in “Electrical Drives, Compact” or “Electrical Drives”, not in both of them.

**Year:**

M.Sc. (Tech.) 1

**Period:**

2-3

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, D.Sc. (Tech.) Juha Pyrhönen

**Aims:**

Upon completion of the course the student will be able to: 1. understand the role of electrical drives, 2. understand different torque producing principles in different machines, 3. model and simulate a DC motor drive, 4. describe the principles of scalar, vector and direct torque control of rotating field machines, 5. define and understand the functioning of the most important power electronic converters, 6. discuss the principles of PWM in general, space vector modulation and DTC, 7. model the behaviour of permanent magnet synchronous machine by using vector equivalent circuits and vector diagrams, 8. understand synchronous machine control in details, 9. understand synchronous reluctance machine control in details, 10. understand the role of induction machine and its control in details, 11. know the switched reluctance machine control principles, 12. discuss the adverse effects of PWM systems on motor behaviour and the wave nature of the motor cable. Mastering the course material well gives the student comprehensive understanding of the basics of electrical drives and wide possibilities to work in the field. This is the course for drives professionals.

**Contents:**

Theory of electric motor drives, operation and vector equivalent circuits. Synchronous machine drives, asynchronous machine drives, synchronous reluctance machine drives, permanent magnet synchronous machine drives, switched reluctance motor drives. Torque production in different machines. Power electronic converters suitable for motor and generator drives. Scalar control, vector control, direct flux linkage control and direct torque control (DTC). Motor cable wave nature, bearing currents. Applying the principles for practical electrical machine types.

**Teaching Methods:**

Lectures 24 h, tutorials 24 h, 2nd period. Lectures 24 h, tutorials 24 h, 3rd period. Independent study including homework tasks 109 h. Examination 3 h.
Total workload 208 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

Yes

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, written examination 100 %.
OR Pass/fail via good enough independent homework.

**Course Materials:**

Lecture material in Moodle.
The course is based on the book: Pyrhönen, Hrabovcova, Semken: “Electrical Machine Drives Control: An Introduction”, published by John Wiley et Sons 2016

**Prerequisites:**

The students are recommended to have completed the courses BL30A0000 Electric Circuits, BL10A0100 Basics of Electric Engineering, BL30A0200 Laboratory Course in Electrical Engineering, BL30A0500 Introduction to Electrical Drives and BL30A0800 Electromagnetic Components and to have attended the course BL30A0400 Design of an Electrical Machine.

**Places for exchange-students? (Yes, number/No):**

15–

**Places for Open University Students?(Yes, number/No):**

max 5

### BL30A1200: Numerical Methods in Electromagnetism, 4 cr

**Validity:** 01.08.2007 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Janne Nerg

**Year:**

M.Sc. (Tech.) 2

**Period:**

3

**Teaching Language:**

English

**Teacher(s) in Charge:**

Associate professor, D.Sc. (Tech.) Janne Nerg

**Aims:**

Upon completion of the course the student will be able to model and analyse electrical machines using commercial finite element based calculation software.

**Contents:**

The fundamentals of the element method, boundary conditions, modelling of materials, post-processing of results. Iron loss models. Eddy current problems, utilisation of circuit model in calculation.

**Teaching Methods:**

28 h of supervised tutorials. 3rd period. Self study: assignment and report 76 h.
Total workload 104 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

Course requirements: participation in tutorials and a satisfactorily completed assignment. 0-5, assignment 100 %.

**Course Materials:**

Course material in Moodle.

**Prerequisites:**

BL30A0500 Introduction to Electrical Drives and BL30A0400 Design of an Electrical Machine.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

max 5

### BL40A1101: Embedded System Programming, 5 cr

**Validity:** 01.08.2017 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Jouni Vuojolainen, Tuomo Lindh, Teemu Sillanpää

**Year:**

M.Sc. (Tech.) 1

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Associate professor, D.Sc. (Tech.) Tuomo Lindh

**Aims:**

Upon completion of the course the student will be able to: 1. apply C language and its structures to embedded system programming, 2. form complex data types such as structures, unions and buffers and use these in order to maintain information of different entities (e.g.
processing units), 3. control the registers of a micro controller using C-language, 4. use different PUs of a micro controller, 5. Take into use a real time operation system.

**Contents:**

Design tools, C-language in embedded system programming, utilization of a micro controller environment (registers, timers, buses, A/D conversion etc.). Typical data structures, typical program structures in real-time applications.

**Teaching Methods:**

14 h of lectures, 14 h of tutorials, 1st period. 14 h of lectures, 14 h of tutorials, 2nd period. Assignment. Written examination.
Total workload 130 h.

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, assignment 1 50 %, examination 50 %.

**Course Materials:**

Wolf, W.: Computers as components: principles of embedded computing system design.
Lecture notes.

**Prerequisites:**

Basics of C language.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

This course has 1-5 places for open university students. More information on the web site for open university instructions.

### BL50A0600: Electromagnetic Compatibility in Power Electronics, 2 cr

**Validity:** 01.08.2007 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Juhamatti Korhonen, Pertti Silventoinen

**Note:**

The course is suitable for distance learning.

**Year:**

M.Sc. (Tech.) 2

**Period:**

2

**Teaching Language:**

English

**Teacher(s) in Charge:**

D.Sc. (Tech.) Juhamatti Korhonen

**Aims:**

Upon completion of the course the student will be able to:
1. describe the coupling mechanisms of electromagnetic interference in power electronics,
2. describe the most significant sources of electromagnetic emissions in power electronic systems,
3. provide suitable filter solutions for common-mode filtering, differential-mode filtering, du/dt filtering

and harmonics filtering.

**Contents:**

Power electronics as an interference source, network harmonics, reflection phenomena of cables, conductive RF interference, interference radiation of power electronics, filtering techniques of conductive interference.

**Teaching Methods:**

14 h of lectures, 2st period. Moodle examination, weekly quizzes. Independent work 38 h. Online course. Total workload 52 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

Yes

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, Moodle examination 70 %, weekly quizzes 30 %.

**Course Materials:**

To be announced in class.

**Prerequisites:**

Recommended: Basic knowledge of electromagnetism and electromagnetic fields.

**Places for exchange-students? (Yes, number/No):**

15–

**Places for Open University Students?(Yes, number/No):**

max 10

## SaDDEM: Specialisation in Electricity Market, 60 cr

**Validity:** 01.08.2018 -
**Form of study:**
**Type:** Study module
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F

No course descriptions.

*Alternative module 60 ECTS*

### A350A0200: Introduction to Economics, 6 cr

**Validity:** 01.08.2011 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Business and Management
**Grading:** Study modules 0-5,P/F

**Teachers:** Jorma Sappinen

**Year:**

B.Sc. (Econ. & Bus. Adm.) 1-2

**Period:**

1-4

**Teaching Language:**

English

**Teacher(s) in Charge:**

Associate Professor, Ph.D. Jorma Sappinen

**Aims:**

By the end of the course, students will be able to describe the principles of modern market economy. Students will be able to explain the basic concepts of microeconomics and macroeconomics and can apply models of consumer, firm, markets and economy in simple situations. In addition, students can analyse the role and consequences of monetary and fiscal policy.

**Contents:**

Principles of microeconomics and macroeconomics. Demand, supply and market equilibrium, production and markets for the factors of production, economics of the public sector. Economic growth, unemployment, inflation, economic fluctuations, monetary and fiscal policy.

**Teaching Methods:**

Independent preparation for written exam 160 h. Total workload for student 160 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

Yes

**Assessment:**

Grade 0-5, evaluation 0-100 points, written exam in the room for electronic exams.

**Course Materials:**

1. Mankiw, N.G. - Taylor, M.P.: Economics, 1st, 2nd, 3rd or 4th ed.

**Places for exchange-students? (Yes, number/No):**

15–

**Places for Open University Students?(Yes, number/No):**

No

### BH50A1200: Energy Systems Engineering, 6 cr

**Validity:** 01.08.2007 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Esa Vakkilainen, Juha Kaikko

**Year:**

M.Sc. (Tech.) 1

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Docent, D.Sc. (Tech.) Juha Kaikko, D.Sc. (Tech.) Ekaterina Sermyagina

**Aims:**

Upon completion of thecourse the student will be able to 1. describe different types of energy production processes, 2. utilize thermodynamics and heat and mass balances inthe design of small scale energy systems, 3. use a “Systems Engineering” type approach to define the design values for energy production processes, 4. define small scale bioenergy production projects, 5. understand how plant requirements affect the planning and implementation phases of small energy systems, and 6. define economic constraints to small scale energy processes.

**Contents:**

History and fundamentals of thermodynamics and energy engineering. Modern problems of power plan tengineering. Combined heat and power production, especially from biomass. Fundamentals of steam and gas turbines in energy production. Engineering design: heat and mass balances in the design of small scale energy systems. Systems engineering. Planning and implementation of energy systems. Economic optimization of energy system projects.

**Teaching Methods:**

1st period: 12 h of lectures and case exercises. 2nd period: 12 h of lectures and case exercises.Written assignment, written examination. Independent study approximately:Written assignment 80 h. Preparation for the examination 16 h and the examination3 h. Studying given material 33 h.
Total workload 156 h.

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0 - 5. Examination 50 %,written assignment 50 %.

**Course Materials:**

Lecture notes.

**Prerequisites:**

Understanding of basic thermodynamics.

**Places for exchange-students? (Yes, number/No):**

max 5

**Places for Open University Students?(Yes, number/No):**

max 5

### BL20A0201: Power Exchange Game for Electricity Markets, 3 cr

**Validity:** 01.08.2007 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Nadezhda Belonogova, Samuli Honkapuro

**Year:**

M.Sc. (Tech.) 1

**Period:**

2-3

**Teaching Language:**

English

**Teacher(s) in Charge:**

M.Sc. (Tech.) Nadezda Belonogova

**Aims:**

Upon completion of the course the student will be able to: Plan electricity purchase and sale in an economically viable way, recognize the most common risk management instruments and basic mechanisms of demand response in electricity markets, and exploit financial products of the power exchange in risk management and trade electricity in day ahead and intraday markets. These skills will be practised in a power exchange game, after which the student will be able to analyse and interpret the game results.

**Contents:**

Electricity purchase/sale, OTC markets, physical products on the power exchange (Elspot and Elbas), financial products on the power exchange (DS Futures and Futures), risk management.

**Teaching Methods:**

Lectures 8 h, weekly game situation practice 40 h, 2nd and 3rd period. Written homework 4h, intermediate report 4h and final report 10h. Independent work 12h. The lectures focus on the key learning objectives in the topic. Successful completion of the course requires student's active independent work.
Total workload 78 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, written report 100 %.

**Course Materials:**

Course material in Moodle.

**Prerequisites:**

BL20A0401 Electricity Market.

**Places for exchange-students? (Yes, number/No):**

max 5

**Places for Open University Students?(Yes, number/No):**

max 5

## BL20A0401: Electricity Market, 5 cr

**Validity:** 01.08.2007 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Samuli Honkapuro

**Year:**

M.Sc. (Tech.) 1

**Period:**

1

**Teaching Language:**

English

**Teacher(s) in Charge:**

Associate Professor, D.Sc. (Tech.) Samuli Honkapuro

**Aims:**

Upon completion of the course the student will be able to: 1. describe the characteristics of the different business sectors in the Nordic electricity market, 2. explain electricity price formation, 3. explain the operation principle of the power exchange, 4. identify and describe
the products of the power exchange, 5. select the right risk management method for electricity trade, 6. describe the tasks of the different parties in an electric power system in maintaining technical and commercial power balance, including demand side management.

**Contents:**

The restructuring of the electricity markets, power exchange, electricity trade, balance management.

**Teaching Methods:**

28 h of lectures 10 h optional Moodle quizzes 1st period. 89 h independent studies. Written examination 3 h.
Total workload 130 h

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, examination 100%. Non-mandatory Moodle quizzes provide extra points to exam.

**Course Materials:**

Material distributed in Moodle.

**Places for exchange-students? (Yes, number/No):**

15–

**Places for Open University Students?(Yes, number/No):**

max 15

### BL20A1300: Energy Resources, 6 cr

**Validity:** 01.08.2014 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Michael Child, Christian Breyer

**Year:**

M.Sc. (Tech.) 1

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, D.Sc. (Tech.) Christian Breyer

**Aims:**

Upon completion of the course the student will be able to: 1. Identify the constraints and potentials of all relevant energy sources in a global context. 2. Describe all relevant energy conversion technologies on the basis of their energy resource. 3. Analyse the principal structure of future energy systems on the basis of energy resource characteristics. 4. Describe the special relevance of wind energy and solar energy in the ongoing energy transformation.

**Contents:**

The course provides an overview on the availability of energy resources and related emissions and techno-economic maturity of related energy conversion technologies, which induces a fundamental structure for the future energy system and the related energy transformation pathway. The course comprises the main energy resources for the current and future energy system: crude oil,natural gas, coal, uranium, hydro power, bioenergy, solar energy, wind energy,geothermal energy, and ocean energy. These energy resources have different theoretical, technical and economic potentials as well as geographic variations in availability. The resources also differ considerably in the impact of the emissions related to the respective energy conversion technologies being relevant for the degree of sustainability. A broad variety of energy conversion technologies at different levels of maturity are used for utilizing the resources.

**Teaching Methods:**

Lectures 14 h, exercises 14 h, 1st period. Lectures 14 h,exercises 14 h, 2nd period. Examination 3h. Independent study 97 h.
Total workload 156 h.

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, examination 100%.

**Course Materials:**

Material handed out in class and made available on Moodle.

**Places for exchange-students? (Yes, number/No):**

15–

**Places for Open University Students?(Yes, number/No):**

max 5

## BL40A2910: Electric Energy Conversion Systems, 4 cr

**Validity:** 01.08.2017 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Olli Pyrhönen, Pasi Peltoniemi

**Year:**

M.Sc. (Tech.) 2

**Period:**

1

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, D.Sc. (Tech.) Olli Pyrhönen

**Aims:**

The student knows the most relevant electrical power conversion solutions in industrial and power system applications. He/she get knowledge of system topologies, main components and control principles in the selected application fields. He/she is able to make basic system design, component selection and dimensioning according to application specifications.

**Contents:**

Marine vessel power system technology, system layout, components and control principles. Electric vehicle and hybrid work machine power system technology, components and control principles. Industrial drive applications, components and control principles. Electrochemical conversion system applications, components and control principles. Examples of different applications. Component selection and dimensioning. Examples of existing system solutions in different application fields.

**Teaching Methods:**

14 hours of lectures, 1st period. 6-7 h Visiting lectures from industry, 2nd period. Assignment 1st and 2nd period 40 h.
Written examination 3 h. Independent working 40 h.
Total workload 104 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

Yes

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5. Written examination (70%), assignment (30%).

**Course Materials:**

Lecture material.

**Prerequisites:**

Electrical Drives, Compact
Power Electronics
Säätötekniikan perusteet /Introduction to Control Engineering

**Places for exchange-students? (Yes, number/No):**

Yes, max 10

**Places for Open University Students?(Yes, number/No):**

No

### BL10A8600: Master's Thesis, 30 cr

**Validity:** 01.08.2015 -
**Form of study:** Basic studies
**Type:** Master's Thesis
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Katja Hynynen

**Note:**

In Master’s programmes taught in English, the Master’s thesis is always prepared in English.

**Year:**

M.Sc. (Tech.) 2

**Period:**

1-4

**Teaching Language:**

English

**Teacher(s) in Charge:**

Post-doctoral researcher, D.Sc. (Tech.) Katja Hynynen

**Aims:**

Upon completion of the course the student will be able to: 1. delineate a research problem, 2. select research methodology suitable for the study, 3. find relevant reference material and assess the credibility of sources, 4. apply the material correctly to his/her own work, 5. write
a scientific report according to scientific practices with a special reference to electrical engineering.

**Contents:**

Fundamentals of scientific work. Good scientific conduct associated with definition of a research problem, selection of research methodology, problem solving and scientific reporting with special focus on electrical engineering practices. Application of scientific knowledge to problem solving. Good information processing skills. Scientific reporting. Information search. Scientific writing skills. Writing the M.Sc. thesis.

**Teaching Methods:**

M.Sc. thesis, 780 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, M.Sc. thesis 100 %.

**Course Materials:**

Course material in Moodle. Master's thesis instructions in Uni portal.

**Prerequisites:**

B.Sc. (Tech.) degree (not required for students admitted directly into a Master's programme).

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

No

## SaDYdin: , 18 - 36 cr

**Validity:** 01.08.2016 -
**Form of study:** Basic studies
**Type:** Study module
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F

No course descriptions.

*Pakolliset ydinopinnot 12-13 op. Ydinopintoihin kuuluu pakollista työharjoittelua 2 op. Obligatory core studies 12-13 ECTS cr. The extent of obligatory work internship in general studies is 2 cr.*

### BL10A8000: Work internship in Master's degree, 2 - 10 cr

**Validity:** 01.08.2012 -
**Form of study:** Practise
**Type:** Practical training
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Simo Hammo

**Note:**

This course also covers activities in student organisations, guilds or the board of the student union, 3-6 ECTS (work of one to two years).
A written report, assessment pass/fail.

**Year:**

M.Sc. (Tech.) 1-2

**Period:**

1-4

**Teaching Language:**

Finnish and English

**Teacher(s) in Charge:**

Laboratory engineer, Lic. Tech. Simo Hammo

**Aims:**

After the work environment internship, the student has obtained a basic knowledge of the work, work environment and working community in his/her own field. The student is able to apply and generalise knowledge and skills acquired during the course of studies to work in
his/her own field.

**Contents:**

The student obtains a (summer) job from the company, works as a paid employee, requests a certificate of employment and applies for the approval of the work as an internship for the Master’s degree. Full-time employment relationships of at least four weeks can be approved
as internships. The completion of the Master’s thesis is not accepted as an internship. An employment

relationship that took place before the studies can be approved as an internship providing that it has not been accepted and included in any other previous degree.

**Teaching Methods:**

First 2 ECTS credits: applying for a job and recruiting 10 h, tasks connected to starting an employment relationship (e.g. orientation, the rules of the employment relationship and the work place) 15 h, observing (while working) how the working community operates (e.g. how work/production is organised, supervision, the working manners of the working community/teams, the social environment of the work place) 22 h, a written internship report 5 h (2-3 pages), total 52 h. 3-10 ECTS credits: having different tasks in a company 26-208 h (1 ECTS credit/26 h). The number of ECTS credits of compulsory internship varies depending on the study programme in question, further information is available in the degree structures of the study guide. Total workload 52-260 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

Pass/Fail, internship report 100%.

**Course Materials:**

Instructions and forms: https://uni.lut.fi/en/web/lut.fi-eng/forms1

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

No

### BL40A2301: Energy Efficiency, 6 cr

**Validity:** 01.08.2013 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Jero Ahola, Tero Ahonen, Lasse Laurila, Antti Kosonen, Tero Kaipia

**Note:**

The course is suitable for distance learning.

**Year:**

M.Sc. (Tech.) 1

**Period:**

4

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, D.Sc (Tech.) Jero Ahola

**Aims:**

Upon completion of the course the student will be able to: 1. determine actions for the energy efficiency of the energy conversion process, 2. estimate the overall energy efficiency of the energy conversion system, 3. identify applications of electric energy usage and apply
methods that can be used to improve the energy efficiency.

**Contents:**

The course provides the student with an introduction to the significance and development potential of energy efficiency in energy production, transmission, distribution and end use. The focus is on electric energy and systems approach. The lecture topics are the efficiency of
energy production processes, the efficiency of electricity transmission and distribution and the efficiency of energy end use. The course is arranged as a series of lectures delivered by experts. The lecture topics may vary from year to year.

**Teaching Methods:**

Lectures 12 h, individual home works 141 h, examination 3 h. The course is suitable for distance learning. Total workload 156 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

Yes

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, examination 100%. In addition, 70 % of individual assignments have to be passed. It is also possible to receive additional points to the exam based on the individual assignments.

**Course Materials:**

Lecture material in Moodle.

**Places for exchange-students? (Yes, number/No):**

15–

**Places for Open University Students?(Yes, number/No):**

max 15

*Keskenään vaihtoehtoiset opintojaksot. Alternative to each other.*

**BL20A0900: Science, Technology and Society, 4 cr**

**Validity:** 01.08.2007 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Johanna Naukkarinen, Karl-Erik Michelsen

**Note:**

E-learning course starting in every period.

**Year:**

M.Sc. (Tech.) 1

**Period:**

1,2,3,4

**Teaching Language:**

Finnish

**Teacher(s) in Charge:**

Professor, Ph.D. Karl-Erik Michelsen, Post-doctoral researcher, D.Sc. (Tech.) Johanna Naukkarinen

**Aims:**

After the course student will be able to:
- understand the interplay between science, technology and society
- analyze the themes presented in the course from different viewpoints
- present a justified opinion on the effects of technology on society and connect his/her views to the larger societal debate
- discuss societal issues within his/her professional area with public with a non-technical background.

**Contents:**

Course discusses the interplay between science, technology and society fromseveral different angles through six specific themes. Some of the themes may changeyearly, but the themes related with risks, gender, ethics and sustainability ortechnology are present every year in some format.

**Teaching Methods:**

Course is an online-course with following learning tasks:
- getting acquainted with the teaching materials in each theme (videos, podcasts and written material) and writing a blog text related with them
- giving peer feedback on certain blog texts
- writing a larger concluding essay on a given topic
- taking a Moodle-quiz.

The workload of the course is as follows: six weekly learning tasks 6 x 10 h, essay 40 h, Moodle-quiz 2 h, peer feedback 2 h.
Total workload 104 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

Yes

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5. Essay 50 %, blog texts 30 %, Moodle-quiz 20 %

**Course Materials:**

Learning materials in Moodle.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

No

### BL20A0910: Technology and Society, 4 cr

**Validity:** 01.08.2017 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F

**Teachers:** Johanna Naukkarinen

**Note:**

Course is taught fully on-line and continuously rolling (no tie to the LUT periods)
Enrolment by e-mail to post-doctoral researcher Johanna Naukkarinen.

**Year:**

M.Sc. (Tech.) 1-2

**Period:**

1-4

**Teaching Language:**

English

**Teacher(s) in Charge:**

Johanna Naukkarinen, D.Sc. (Tech.), Post-doctoral researcher

**Aims:**

Upon completion of the course the student will be able to:
1. understand and explain the general interplay between technology and society
2. analyze the possible effects of different technologies on society
3. evaluate how the societal factors may affect the development and dissemination of different technologies.

**Contents:**

Social and economic factors affecting the development and adoption of technologies, mechanisms of interplay between society and technology, predicting the potential impact of technology.

**Teaching Methods:**

The completion of the course consist of completing the learning tasks in a topic related massive open online -course (MOOC) of teacher's choice and keeping a learning diary. The MOOC will be announced at the beginning of the academic year. Formal passing or a certificate on completion of the MOOC is not required, but student has to proof that all the required assignments have been sufficiently done.
Total workload 104 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

Grading on a scale 0-5
50 % of the assessment is based on the quality of MOOC learning assignment and 50 % on the quality of the learning diary. More exact assessment matrix can be found on course Moodle-area.

**Course Materials:**

The content of the chosen MOOC, article(s) provided in the Moodle-area

**Limitation for students? (Yes, number, priorities/Leave empty):**

Primarily for M.Sc students in electrical engineering, energy technology and circular economy.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

No

*Vain opiskelijoille, jotka eivät ole suorittaneet kandidaatin opintoja LUT:ssa. Only for the students who have not studied their Bachelor's studies at LUT.*

**BH60A4600: Introduction to M.Sc. Studies, 1 cr**

**Validity:** 01.08.2013 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Sanni Väisänen, Marjaana Lehtinen, Risto Soukka, Aki-Pekka Grönman, Katja Hynynen

**Note:**

Lectures together withall students of International Master's programs in Energy Technology, Electrical Engineering, Mechanical Engineering and Sustainability Science and Solutions.
Lectures for students of MSc programme in Circular Economy will be arranged in Lahti or online (announced in the beginning of the course).

**Year:**

M.Sc. (Tech.) 1

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Post-Doctoral Researcher, D.Sc.(Tech.)Sanni Väisänen
Post-Doctoral Researcher, TkT Katja Hynynen
Associate Professor, TkT Ahti Jaatinen-Värri
Researcher, D.Sc.(Tech.) John Bruzzo Escalante

**Aims:**

Upon completionof the course the student is expected to be able to:
1. describe the content of the Degree Programme, interpret the study guide andalso describe the research areas of School of Energy Systems,
2. prepare his/her individual study plan (ePSP) and follow the progress ofhis/her studies with the help of WebOodi's personal study plan,
3. observe the university's examination practices and degree programmepractices (incl. instructions of the Master's Thesis),
4. use the services of the library, retrieve information independently and usethe information sources in accordance with good practices, and also toobserve the copyrights,
5. understand how to manage the studies and how to find help when needed duringhis/her studies,
6. use the Moodle learning environment,
7. knowshow to improve information security during his/her daily use ofuniversity networks,
8. understandthe concept of career planning and use the services of career services,
9. understand the concept of cultural differences and how it mighteffect on his/her daily social intercourse.

**Contents:**

Getting to know the School of EnergySystems and the Master's programs Studies (incl. Master's Thesis). Studyand exam culture in LUT. LUT library collections, databases,reference practices, and copyrights, information security, career planningand cultural difference related issues. Study Skills and Motivation. ePSPworkshop. Research areas of School of Energy Systems. The course is related to sustainability.

**Teaching Methods:**

1st and 2nd period: 15 hof obligatory lectures (incl. participation in an ePSP workshop. 1stperiod: Information security training and Information searchning web courses (2+ 5 h). 2nd period: Individual discussion with a teacher tutor 1 h. Individualwork 3 h. Total workload 26 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

Pass/fail. Passing the course requires attendance at the lectures, ePSP, passing individual Information security training and Information searching web courses, written assignment, and discussion with teacher tutor.

**Course Materials:**

Study Guide, Moodle, LUT library collections, and databases.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

No

*Laboratorio/työkursseja suoritetaan vähintään 6 op. The student takes 6 cr. at the minimum of at least one of the laboratory courses.*

**BL30A1102: Laboratory Course in Electrical Power Engineering, 3 - 8 cr**

**Validity:** 01.08.2017 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Jukka Lassila, Lasse Laurila, Juha Haakana, Vesa Ruuskanen, Tero Kaipia, Ville Tikka, Hannu Kärkkäinen

**Year:**

M.Sc. (Tech.) 1-2

**Period:**

1-4

**Teaching Language:**

Finnish and English

**Teacher(s) in Charge:**

Associate professor, D.Sc. (Tech.) Lasse Laurila / electric drives
Associate professor, D.Sc. (Tech.) Jukka Lassila / electricity networks

**Aims:**

Upon completion of the course the student will be able to: 1. plan and execute measurements in laboratory on electric drives, motors, power electronics and/or electric networks, 2. analyse measurement results, 3. analyse databases of electric networks, 4. write good-quality technical reports, 5. participate in electrical measurement activities in laboratory environments.

**Contents:**

Laboratory works on electric drives, motors, power electronics and/or networks. Design, measurements, simulations, analysis and reports. Electrical safety.

**Teaching Methods:**

Introductory lecture, 1 h, 1.period. Laboratory work, computer-aided work, writing of preliminary reports and measurement reports. 1st-4th period on M.Sc. (Tech.) 1, 1st -2nd period on M.Sc. (Tech.) 2. The lecturers responsible for the course give further information about the laboratory assignments and prerequisites of each assignment. Measurements in laboratory 18-64 h, 1st-4th period. Independent study: Measurement analysis and report writing 50-112 h, simulations 10-32 h. The number of credits differs by laboratories: Electricity Market and
Power Systems 8 cr, Electrical Drives Technology 6-8 cr. For students taking Master's degree programme for adult learners and students in international Master's programmes taught in English 3 cr.
Total workload 78-208 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, measurements and reports in groups of three persons (personal grades) 100 %.

**Course Materials:**

Course material in Moodle

**Prerequisites:**

BL30A0201 Laboratory Course in Electrical Engineering (Sähkötekniikan työkurssi) or equivalent completed.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

max 5

## BL40A0601: Laboratory Course in Control Systems and Signal Processing, 2 - 6 cr

**Validity:** 01.08.2017 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Antti Kosonen, Tuomo Lindh

**Year:**

M.Sc. (Tech.) 1

**Period:**

1-4

**Teaching Language:**

Finnish/English

**Teacher(s) in Charge:**

Associate Professor, D.Sc. (Tech.) Antti Kosonen, Associate Professor, D.Sc. (Tech.) Tuomo Lindh

**Aims:**

Upon completion of the course the student will be able to: 1. apply the theory he/she has learned in the previous courses of control engineering and digital signal processing, 2. design, implement and analyse different technical systems by simulating with Matlab/Simulink
software and laboratory equipment, 3. report the work.

**Contents:**

Design and methods of analysis of the most common continuous and discrete time control systems, modelling of dynamic systems, discretisation of a continuous time system, simulation of dynamic systems. Implementation and testing of control systems in the
laboratory. Design and methods of analysis of digital signal processing systems. Programming of digital signal processing systems. Practical aspects and demands in implementing a control system. Programming of embedded signal processing systems.

**Teaching Methods:**

Computer and laboratory assignments, 1st-4th period. Independent study 52-156 h.
Total workload 52-156 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Doctoral School course where enrollment is in WebOodi (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, assignments 100 %. The course must be accomplished in two years.

**Prerequisites:**

Content of the following courses to the appropriate extent: BL40A0200 Säätötekniikan perusteet A or BL40A0300 Säätötekniikan perusteet B, BL40A0401 Signaalien digitaalinen käsittely I, BL40A0501 Digitaalisäädön perusteet, BL40A1202 Digital Control Design, and
BL40A0810 Digital signal processing II.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

This course has 1-5 places for open university students. More information on the web site for open university instructions.

### BL50A1600: Electronics, Laboratory Course 2, 3 - 6 cr

**Validity:** 01.08.2013 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Tommi Kärkkäinen

**Year:**

M.Sc. (Tech.) 1-2

**Period:**

1-4

**Teaching Language:**

Finnish

**Teacher(s) in Charge:**

Post-doctoral researcher, D.Sc. (Tech) Tommi Kärkkäinen

**Aims:**

Upon completion of the course the student will be able to: 1. apply theoretical studies of other courses to practical electronics design, problem solving and prototype construction, 2. use multimeters, oscilloscopes, signal generators, power supplies and other measuring instruments, 3. analyse the operation of circuits based on measurements, 4. produce a scientific, technical report, 5. act as a team member in an electronics project and bear their responsibility of the success of the project.

**Contents:**

Electronics laboratory work and prototype testing, the use of measuring instruments. Electronics design, testing, troubleshooting, hand soldering, electronics circuit simulation, project work and project management.

**Teaching Methods:**

Defining, implementing and documenting an electronics project. Electronics design, laboratory work and reporting, 1st-4th period. Personal assignments 16 h, project work 62-138 h.
Total workload 78-156 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

1-5. Assessment based on the produced documentation and the success of the project 80 %, and personal tasks 20 %.

**Course Materials:**

Moodle material, material announced in class.

**Prerequisites:**

BL50A0502 Electronics, Laboratory Course 1.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

max 5

**Description and DL of the company assignment:**

Small and simple electronics design projects are carried out on the course. The students write a specification document for the device to be constructed, build a prototype and test and document the outcome of the project.
Deadline for the assignments is 31.8. Contact: Tommi Kärkkäinen, tommi.karkkainen@lut.fi, +358 40 148 8341

## SaDEESpec: Specialisation Studies in Electrical Engineering, 70 cr

**Validity:** 01.08.2017 -

**Form of study:**
**Type:** Study module
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F

No course descriptions.

*Master's thesis 30 ECTS cr.*

**BL10A8600: Master's Thesis, 30 cr**

**Validity:** 01.08.2015 -
**Form of study:** Basic studies
**Type:** Master's Thesis
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Katja Hynynen

**Note:**

In Master’s programmes taught in English, the Master’s thesis is always prepared in English.

**Year:**

M.Sc. (Tech.) 2

**Period:**

1-4

**Teaching Language:**

English

**Teacher(s) in Charge:**

Post-doctoral researcher, D.Sc. (Tech.) Katja Hynynen

**Aims:**

Upon completion of the course the student will be able to: 1. delineate a research problem, 2. select research methodology suitable for the study, 3. find relevant reference material and assess the credibility of sources, 4. apply the material correctly to his/her own work, 5. write
a scientific report according to scientific practices with a special reference to electrical engineering.

**Contents:**

Fundamentals of scientific work. Good scientific conduct associated with definition of a research problem, selection of research methodology, problem solving and scientific reporting with special focus on electrical engineering practices. Application of scientific knowledge to problem solving. Good information processing skills. Scientific reporting. Information search. Scientific writing skills. Writing the M.Sc. thesis.

**Teaching Methods:**

M.Sc. thesis, 780 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, M.Sc. thesis 100 %.

**Course Materials:**

Course material in Moodle. Master's thesis instructions in Uni portal.

**Prerequisites:**

B.Sc. (Tech.) degree (not required for students admitted directly into a Master's programme).

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

No

*Elective modules, choose two to three modules to attain a min. of 70 ECTS cr. in the specialisation studies.*

**SaDEIMa: Electricity Market, 22 - 23 cr**

**Validity:** 01.08.2017 -
**Form of study:**
**Type:** Study module
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F

No course descriptions.

*Elective module 22-23 ECTS cr.*

**BL20A0201: Power Exchange Game for Electricity Markets, 3 cr**

**Validity:** 01.08.2007 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Nadezhda Belonogova, Samuli Honkapuro

**Year:**

M.Sc. (Tech.) 1

**Period:**

2-3

**Teaching Language:**

English

**Teacher(s) in Charge:**

M.Sc. (Tech.) Nadezda Belonogova

**Aims:**

Upon completion of the course the student will be able to: Plan electricity purchase and sale in an economically viable way, recognize the most common risk management instruments and basic mechanisms of demand response in electricity markets, and exploit financial
products of the power exchange in risk management and trade electricity in day ahead and intraday markets. These skills will be practised in a power exchange game, after which the student will be able to analyse and interpret the game results.

**Contents:**

Electricity purchase/sale, OTC markets, physical products on the power exchange (Elspot and Elbas), financial products on the power exchange (DS Futures and Futures), risk management.

**Teaching Methods:**

Lectures 8 h, weekly game situation practice 40 h, 2nd and 3rd period. Written homework 4h, intermediate report 4h and final report 10h. Independent work 12h. The lectures focus on the key learning objectives in the topic. Successful completion of the course requires student's active independent work.
Total workload 78 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, written report 100 %.

**Course Materials:**

Course material in Moodle.

**Prerequisites:**

BL20A0401 Electricity Market.

**Places for exchange-students? (Yes, number/No):**

max 5

**Places for Open University Students?(Yes, number/No):**

max 5

### BL20A1600: Smart Grids, 5 cr

**Validity:** 01.08.2016 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Jarmo Partanen, Jukka Lassila, Samuli Honkapuro, Tero Kaipia

**Note:**

The course is suitable for distance learning.

**Year:**

M.Sc. (Tech.) 1-2

**Period:**

3-4

**Teaching Language:**

English

**Teacher(s) in Charge:**

Associate Professor, D.Sc. Samuli Honkapuro

**Aims:**

Upon completion of the course the student will be able to 1. Label the key elements and functionalities of the smart grid system 2. Analyze the impacts of the smart grid elements on

electricity distribution system and electricity markets 3. Document and present orally the results of the seminar work 4. Provide both written and oral peer review.

**Contents:**

Smart grid concept, demand side management, energy storages, distributed generation, microgrids, communications in smart grids. In addition, annually changing topical subjects.

**Teaching Methods:**

Lectures 14 h, Moodle quizzes 7 h in 3rd period. Independent seminar work 100 h. Presentation of the seminar work 2 h,
peer review of a written seminar work 5 h and working as an opponent in seminar 2 h in 4th period. Course is suitable for distance learning.
Total workload 130 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5. The course is evaluated based on seminar work (written and oral presentation), Moodle quizzes, and student's work as a reviewer and an opponent.

**Course Materials:**

Study materials handed out in Moodle.

**Prerequisites:**

Attending the course BL20A0500 Sähkönjakelutekniikka (Electricity distribution) OR BL20A0401 Electricity Market OR BL20A0400 Sähkömarkkinat (Electricity Market)

**Places for exchange-students? (Yes, number/No):**

max 10

**Places for Open University Students?(Yes, number/No):**

max 5

### BH60A4400: Introduction to Sustainability, 3 cr

**Validity:** 01.08.2013 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Mirja Mikkilä, Virgilio Panapanaan, Risto Soukka

**Year:**

M.Sc. (Tech.) 1

**Period:**

1

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, D.Sc. (Tech.) Risto Soukka

**Aims:**

Upon completion of the course the students are expected to be able to:
1) explain the interaction between the environment, society and business and understand the relationships of various actors in these fields and their impacts on the society and the environment,
2) understand the core idea and thinking behind sustainability and its importance in order to limit or decelerate environmental damages and improve our quality of life while pursuing a more sustainable lifestyle and business within the planetary boundaries,
3) understand and apply practically the learned principles and concepts of sustainability in relation to current production and consumption habits,
4) know and be guided about the different value-adding activities and tools that promote sustainability

**Contents:**

The idea is to learn and understand sustainability challenges and their interconnectedness, and find out how we could move or transit towards a more sustainable world.

**Teaching Methods:**

1st period: 14 h of lectures. Independent study (approx. 64 h): assignment (group work) and seminar (approx. 26 h). Preparation for the examination and the exam (approx. 38 h). Total workload 78 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

Yes

**Examination in Exam (Yes/No):**

No

**Assessment:**

0 - 5. Examination 60 %, assignment 40 %.

**Course Materials:**

Will be announced during lectures. Moodle.

**Places for exchange-students? (Yes, number/No):**

max 5

**Places for Open University Students?(Yes, number/No):**

max 5

### BH60A5700: Business and Sustainability, 6 cr

**Validity:** 01.01.2018 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F

**Note:**

Replaces the course BH60A3001 Corporate Responsibility and Management 2.

**Year:**

M.Sc. (Tech.) 1

**Period:**

3-4

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, D.Sc. (Econ. & Bus. Adm.), M.Sc. (Tech.) Lassi Linnanen
Associate Professor, D.Sc. (Agr. & For.) Mirja Mikkilä

**Aims:**

Upon the completion of the course the student is expected to be able to:
1. analyze decision making situations related to sustainable business,
2. propose solutions to challenging business situation within sustainable business,
3. understand various sustainable business and enterprise models,
4. evaluate critically responsible corporate communication,
5. discuss and argument on various perspectives of sustainable business based on the learned issues and on-going societal debate.
6. carry out self- and peer evaluations

**Contents:**

Familiarization with the sustainable business models and the strategic responsibility framework of a firm. Reorganization of dimensions of responsible business. Deepening the application skills of mechanisms and tools of sustainable management. Analysisof business and financial consequences of responsibility governance. Familiarization of basics of business ethics. Communication and reporting ofgoals and implementation of corporate responsibility to stakeholders. Learning of corporate responsibility reporting guidelines.

**Teaching Methods:**

Lectures 6 h, 3 period. Written report on Corporate Responsibility communication and preparation of seminar presentation, groupwork approximately 30 h, written report 3 period.
Seminar presentation 4. period. Case-assignments, group work, approximately 120 h, 3-4 period. The student mustparticipate in the case-assignments.
Total workload 156 h, of which independent work approximately 118 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Doctoral School course where enrollment is in WebOodi (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

Evaluation 0 - 5. Written report 30 %, case-assignments 70 %.

**Course Materials:**

Caset: Hamschmidt, Jost (toim.): Case studies in sustainability management and strategy: the Oikos collection, 2007,
Pirson, Michael (toim.): Case studies in social entrepreneurship: the Oikos collection, 2015,
GRI yhteiskuntavastuun raportointiohjeisto, versiot 3.1 ja 4. Further course material will beannounced during the lectures,
Course material in Moodle

**Prerequisites:**

Sustainability transition and sustainable business (Kestävyysmuutos ja johtaminen) or Introduction to Sustainable Business
passed or equivalent knowledge studied earlier.

**Places for exchange-students? (Yes, number/No):**

Max 5

**Places for Open University Students?(Yes, number/No):**

Max 5

*Choose Electricity Market, if you have not studied it earlier. Otherwise, choose Investointihankkeiden elinkaarilaskelmat (taught in Finnish only).*

**BL20A0401: Electricity Market, 5 cr**

**Validity:** 01.08.2007 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Samuli Honkapuro

**Year:**

M.Sc. (Tech.) 1

**Period:**

1

**Teaching Language:**

English

**Teacher(s) in Charge:**

Associate Professor, D.Sc. (Tech.) Samuli Honkapuro

**Aims:**

Upon completion of the course the student will be able to: 1. describe the characteristics of the different business sectors in the Nordic electricity market, 2. explain electricity price formation, 3. explain the operation principle of the power exchange, 4. identify and describe
the products of the power exchange, 5. select the right risk management method for electricity trade, 6. describe the tasks of the different parties in an electric power system in maintaining technical and commercial power balance, including demand side management.

**Contents:**

The restructuring of the electricity markets, power exchange, electricity trade, balance management.

**Teaching Methods:**

28 h of lectures 10 h optional Moodle quizzes 1st period. 89 h independent studies. Written examination 3 h.
Total workload 130 h

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, examination 100%. Non-mandatory Moodle quizzes provide extra points to exam.

**Course Materials:**

Material distributed in Moodle.

**Places for exchange-students? (Yes, number/No):**

15–

**Places for Open University Students?(Yes, number/No):**

max 15

### CS31A0610: Life-Cycle Costing of Investment Projects, 6 cr

**Validity:** 01.08.2016 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Business and Management
**Grading:** Study modules 0-5,P/F
**Teachers:** Timo Kärri, Sini-Kaisu Kinnunen

**Note:**

Can't be included into a same degree as CS31A0603 Life-Cycle Costing of Investment Projects.

**Year:**

M.Sc. 1-2

**Period:**

1

**Teaching Language:**

Finnish

**Teacher(s) in Charge:**

Professor, D.Sc. (Tech.) Timo Kärri
M.Sc. (Tech.) Sini-Kaisu Kinnunen

**Aims:**

After completing the course students will be able to:
- prepare and evaluate investment proposals
- analyze requirements of sustainability during the life-cycle of projects.

**Contents:**

Investment proposal. Life-cycle of investment project, life-cycle costs and profits, capital costs, initial investment and working capital, classification and selection of projects, uncertainty and risks. Evaluation methods introduced: net present value, internal rate of return, return on investment, payback period, benefit-cost ratio and profitability index. Investment process, timing and financing of projects, public-private partnership, life-cycle models of machine replacements, concept of real option, evaluation of projects from the perspective of sustainability.

**Teaching Methods:**

Lectures 26 h, exercises 10 h, micro-execises 9 h, homeworks 12 h, individual tasks 64 h, preparation for exam and exam 36 h, 1. period. Total 157 h.

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0 - 5. Exam, extra points from assignments.

**Course Materials:**

Lecture notes (2 copies). Mott, Graham: Investment appraisal. Pitman Publishing, 1997, (196 p.). Götze U. et al: Investment appraisal - Methods and models. Springer. 2008, (341 p.)

**Prerequisites:**

CS31A0102 Kustannusjohtamisen peruskurssi

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

max 5

**SaDEIDri: Electrical Drives, 25 cr**

**Validity:** 01.08.2017 -
**Form of study:**
**Type:** Study module
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F

No course descriptions.

*Elective module 25 ECTS cr.*

**BL30A0600: Power Electronics, 6 cr**

**Validity:** 01.08.2007 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Lasse Laurila

**Note:**

The course is suitable for distance learning.
Course has examination in Examination schedule, but it is not traditional paper exam. The exam will be done with computer.

**Year:**

M.Sc. (Tech.) 1

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Associate professor, D.Sc. (Tech.) Lasse Laurila

**Aims:**

Upon completion of the course the student will be able to: 1. demonstrate good general knowledge of the different basic main circuits in modern power electronics, 2. describe the features and functions of different rectifiers, switch-mode converters and inverters, 3. calculate and simulate typical design tasks of the aforementioned circuits, 4. describe the joint operation of static converters and loads as well as the network interferences caused by converters and alternatives to reduce these interferences.

**Contents:**

Operation of the main circuits of different power converters: rectifiers (single and three-phase), DC-DC switch mode converters and power supplies (buck, boost, buck-boost, flyback, forward), inverters (single and three-phase), resonance converters (ZVS, ZCS). Characteristics and operation. Pulse width modulation (PWM). Harmonic components. Simulation of power electronic circuits (simulation tools used: PSpice and Matlab/Simulink, calculations on Mathcad, Excel). Possible extra assignments to gather extra points to the exam.

**Teaching Methods:**

Combined lectures and tutorials, 28 h, 1st period. Combined lectures and tutorials, 28 h, 2nd period. Moodle-examination, 3 h. Independent study 97 h. The course is suitable for distance learning.
Total workload 156 h.

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

Yes

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, examination 100 %. 75 % of tutorial tasks passed or 75 % active presence in tutorials. Possible extra assignments to gather extra points to the exam.

**Course Materials:**

Mohan, Undeland, Robbins: Power Electronics, converters, applications, and design. Chapters 1 to 18.
Course material in Moodle.

**Prerequisites:**

Recommended: BL30A0000 Electric Circuits. Integration and derivation (esp. sine and cosine functions).
FFT. Laplace transforms. Basic software skills with Excel, Word.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

max 5

### BL30A0901: Power Electronic Components, 5 cr

**Validity:** 01.08.2016 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Lasse Laurila

**Note:**

The course is suitable for distance learning.
Course has examination in Examination schedule, but it is not traditional paper exam. The exam will be done with computer.

**Year:**

M.Sc. (Tech.) 1

**Period:**

3-4

**Teaching Language:**

English

**Teacher(s) in Charge:**

Lasse Laurila, D.Sc. (Tech.), Associate professor

**Aims:**

After the course the student can: 1. describe the properties, operation and suitable applications of different power electronic devices, passive components and electrical energy storages. 2. calculate the losses of the device and design suitable cooling and protection. 3. Simulate and analyse switching phenomena of power electronic components.

**Contents:**

Basic semiconductor physics, pn-junction, power semiconductor devices, passive components, mobile power electronics, electrical energy storages (batteries, supercapacitors). Operation principles of power electronic switches, switching phenomena, losses, applications. Manufacturing methods, gate and base drive circuits, cooling methods, protection methods. Simulation of power electronic components. Possible extra assignments to gather extra points to the exam.

**Teaching Methods:**

Combined lectures and tutorials, 28 h, 3. period. Combined lectures and tutorials, 28 h, 4th period. Moodle examination 3 h. Independent study 71 h. The course is suitable for distance learning. Total workload 130 h.

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

Yes

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, examination 100 %. 75 % of tutorial tasks passed or 75 % active presence in tutorials. Possible extra assignments to gather extra points to the exam.

**Course Materials:**

Mohan, Undeland, Robbins: Power Electronics, converters, applications, and design. Chapters 19-29.
Course material in Moodle.
Recommended to follow also additional material listed in Moodle and lecture materials.

**Prerequisites:**

BL30A0000 Electric Circuits. Integration and derivation.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

max 5

### BL30A1001: Electrical Drives, 8 cr

**Validity:** 01.08.2010 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Juha Pyrhönen

**Note:**

The first part (2nd period) will be studied in collaboration with BL30A1020 Electrical Drives, Compact. Common lectures, exercises and homework. The student may participate either in “Electrical Drives, Compact” or “Electrical Drives”, not in both of them.

**Year:**

M.Sc. (Tech.) 1

**Period:**

2-3

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, D.Sc. (Tech.) Juha Pyrhönen

**Aims:**

Upon completion of the course the student will be able to: 1. understand the role of electrical drives, 2. understand different torque producing principles in different machines, 3. model and simulate a DC motor drive, 4. describe the principles of scalar, vector and direct torque control of rotating field machines, 5. define and understand the functioning of the most important power electronic converters, 6. discuss the principles of PWM in general, space vector modulation and DTC, 7. model the behaviour of permanent magnet synchronous machine by using vector equivalent circuits and vector diagrams, 8. understand synchronous machine control in details, 9. understand synchronous reluctance machine control in details, 10. understand the role of induction machine and its control in details, 11. know the switched reluctance machine control principles, 12. discuss the adverse effects of PWM systems on motor behaviour and the wave nature of the motor cable. Mastering the course material well gives the student comprehensive understanding of the basics of electrical drives and wide possibilities to work in the field. This is the course for drives professionals.

**Contents:**

Theory of electric motor drives, operation and vector equivalent circuits. Synchronous machine drives, asynchronous machine drives, synchronous reluctance machine drives, permanent magnet synchronous machine drives, switched reluctance motor drives. Torque production in different machines. Power electronic converters suitable for motor and generator drives. Scalar control, vector control, direct flux linkage control and direct torque control (DTC). Motor cable wave nature, bearing currents. Applying the principles for practical electrical machine types.

**Teaching Methods:**

Lectures 24 h, tutorials 24 h, 2nd period. Lectures 24 h, tutorials 24 h, 3rd period. Independent study including homework tasks 109 h. Examination 3 h.
Total workload 208 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

Yes

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, written examination 100 %.
OR Pass/fail via good enough independent homework.

**Course Materials:**

Lecture material in Moodle.
The course is based on the book: Pyrhönen, Hrabovcova, Semken: “Electrical Machine Drives Control: An Introduction”, published by John Wiley et Sons 2016

**Prerequisites:**

The students are recommended to have completed the courses BL30A0000 Electric Circuits, BL10A0100 Basics of Electric Engineering, BL30A0200 Laboratory Course in Electrical Engineering, BL30A0500 Introduction to Electrical Drives and BL30A0800 Electromagnetic Components and to have attended the course BL30A0400 Design of an Electrical Machine.

**Places for exchange-students? (Yes, number/No):**

15–

**Places for Open University Students?(Yes, number/No):**

max 5

### BL40A2810: Automation, 6 cr

**Validity:** 01.08.2017 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Tuomo Lindh, Jan-Henri Montonen

**Year:**

M.Sc. (Tech.) 1

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Associate professor, D.Sc. (Tech.) Tuomo Lindh

**Aims:**

Upon completion of the course the student will be able to: 1. apply automation and digital control theory to practical implementations, 2. use the analog and digital communication techniques applied to automation, 3. apply fieldbuses, 4. formulate a dynamic system model
of motor drives 5. Simulate servo motor driven mechatronic systems, 6. construct controllers and models of dynamic systems using IEC61131-3 and C programming languages, 7. select a proper controller structure, 8. work in a group solving automation and control problems.

**Contents:**

IEC61131-3 programming languages, Feedback devices, Automation hardware and software. Fieldbuses. Basics of servo drive dynamics, Utilizing Simulink models in PLC systems. C/C++ languages in PLC systems. HMI, OPC, IoT in automation. Introduction to safety in automation.

**Teaching Methods:**

Lectures 14 h, exercises 14 h, 1st period.
Lectures 14 h, exercises 14 h, 2nd period.
Independent study: project work 35 h, laboratory exercises 21h
preparation for examination 40 h, examination at Moodle 4 h.
Total workload 156 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

Yes

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, examination 40 %. Project work 60%.

**Course Materials:**

Presentation slides at Moodle.
Karl-Heinz John, Michael Tiegelkamp.IEC 61131-3: Programming Industrial Automation Systems.e-ISBN 978-3-642-12015-2.

**Prerequisites:**

Basics of programming.

**Places for exchange-students? (Yes, number/No):**

Yes, 10.

**Places for Open University Students?(Yes, number/No):**

This course has 1-10 places for open university students. More information on the web site for open university instructions.

### SaDPoEI: Power Electronics, 19 cr

**Validity:** 01.08.2017 -
**Form of study:**
**Type:** Study module
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F

No course descriptions.

*Elective module 19 ECTS cr.*

#### BL20A0100: Thermal Design of an Electric Device, 3 cr

**Validity:** 01.08.2007 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Janne Nerg

**Note:**

The course is suitable for distance learning.

**Year:**

M.Sc. (Tech.) 1

**Period:**

3

**Teaching Language:**

Finnish

**Teacher(s) in Charge:**

Associate professor, D.Sc. (Tech.) Janne Nerg

**Aims:**

Upon completion of the course the student will be able to 1. perform thermal design of a simple electronic device, 2. describe the heat transfer mechanisms and 3. analytically calculate temperature distribution of an electronic device.

**Contents:**

Heat transfer mechanisms, cooling methods of electronic devices, the effect of the operation temperature on the performance of an electronic device, thermal resistance networks, numerical calculation methods in thermal engineering.

**Teaching Methods:**

Lectures 14 h, exercises 14 h, home assignments, 3rd period. Examination or continuous assesment. Course is suitable for distance learning. Total workload 78 h.

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0–5, examination or continuous assesment 100 %.

**Course Materials:**

Course material is found from Moodle.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

max 5

### BL30A0600: Power Electronics, 6 cr

**Validity:** 01.08.2007 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Lasse Laurila

**Note:**

The course is suitable for distance learning.
Course has examination in Examination schedule, but it is not traditional paper exam. The exam will be done with computer.

**Year:**

M.Sc. (Tech.) 1

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Associate professor, D.Sc. (Tech.) Lasse Laurila

**Aims:**

Upon completion of the course the student will be able to: 1. demonstrate good general knowledge of the different basic main circuits in modern power electronics, 2. describe the features and functions of different rectifiers, switch-mode converters and inverters, 3. calculate and simulate typical design tasks of the aforementioned circuits, 4. describe the joint operation of static converters and loads as well as the network interferences caused by converters and alternatives to reduce these interferences.

**Contents:**

Operation of the main circuits of different power converters: rectifiers (single and three-phase), DC-DC switch mode converters and power supplies (buck, boost, buck-boost, flyback, forward), inverters (single and three-phase), resonance converters (ZVS, ZCS). Characteristics and operation. Pulse width modulation (PWM). Harmonic components. Simulation of power electronic circuits (simulation tools used: PSpice and Matlab/Simulink, calculations on Mathcad, Excel). Possible extra assignments to gather extra points to the exam.

**Teaching Methods:**

Combined lectures and tutorials, 28 h, 1st period. Combined lectures and tutorials, 28 h, 2nd period. Moodle-examination, 3 h. Independent study 97 h. The course is suitable for distance learning.
Total workload 156 h.

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

Yes

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, examination 100 %. 75 % of tutorial tasks passed or 75 % active presence in tutorials. Possible extra assignments to gather extra points to the exam.

**Course Materials:**

Mohan, Undeland, Robbins: Power Electronics, converters, applications, and design. Chapters 1 to 18.
Course material in Moodle.

**Prerequisites:**

Recommended: BL30A0000 Electric Circuits. Integration and derivation (esp. sine and cosine functions).
FFT. Laplace transforms. Basic software skills with Excel, Word.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

max 5

### BL30A0800: Electromagnetic Components, 3 cr

**Validity:** 01.08.2007 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Janne Nerg

**Note:**

The course is suitable for distance learning.

**Year:**

M.Sc. (Tech.) 1

**Period:**

1

**Teaching Language:**

Finnish

**Teacher(s) in Charge:**

Associate professor, D.Sc. (Tech.) Janne Nerg

**Aims:**

Upon completion of the course the student will be able to: 1. design simple transformers and inductors, 2. name and describe magnetic core materials, 3. describe the different loss mechanisms, 4. explain the non-linearities of inductors and transformers at different frequencies, 5. minimise the transformer leakage inductance.

**Contents:**

Faraday’s induction law, Ampère’s law, operation principle of a transformer and an inductor, non-linearities of electromagnetic components, magnetic materials, iron losses and copper losses.

**Teaching Methods:**

14 h of lectures, 14 h of tutorials, 1st period. Home assignments. Examination or continuous assesment. The course is suitable for distance learning.
Total workload 78 h.

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, examination or continuous assesment 100 %.

**Course Materials:**

Course material is found from Moodle.

**Prerequisites:**

BL30A0300 Electromagnetism attended.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

max 5

### BL30A0901: Power Electronic Components, 5 cr

**Validity:** 01.08.2016 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Lasse Laurila

**Note:**

The course is suitable for distance learning.
Course has examination in Examination schedule, but it is not traditional paper exam. The exam will be done with computer.

**Year:**

M.Sc. (Tech.) 1

**Period:**

3-4

**Teaching Language:**

English

**Teacher(s) in Charge:**

Lasse Laurila, D.Sc. (Tech.), Associate professor

**Aims:**

After the course the student can: 1. describe the properties, operation and suitable applications of different power electronic devices, passive components and electrical energy storages. 2. calculate the losses of the device and design suitable cooling and protection. 3. Simulate and analyse switching phenomena of power electronic components.

**Contents:**

Basic semiconductor physics, pn-junction, power semiconductor devices, passive components, mobile power electronics, electrical energy storages (batteries, supercapacitors). Operation principles of power electronic switches, switching phenomena, losses, applications. Manufacturing methods, gate and base drive circuits, cooling methods, protection methods. Simulation of power electronic components. Possible extra assignments to gather extra points to the exam.

**Teaching Methods:**

Combined lectures and tutorials, 28 h, 3. period. Combined lectures and tutorials, 28 h, 4th period. Moodle examination 3 h. Independent study 71 h. The course is suitable for distance learning. Total workload 130 h.

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

Yes

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, examination 100 %. 75 % of tutorial tasks passed or 75 % active presence in tutorials. Possible extra assignments to gather extra points to the exam.

**Course Materials:**

Mohan, Undeland, Robbins: Power Electronics, converters, applications, and design. Chapters 19-29.
Course material in Moodle.
Recommended to follow also additional material listed in Moodle and lecture materials.

**Prerequisites:**

BL30A0000 Electric Circuits. Integration and derivation.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

max 5

### BL50A0600: Electromagnetic Compatibility in Power Electronics, 2 cr

**Validity:** 01.08.2007 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Juhamatti Korhonen, Pertti Silventoinen

**Note:**

The course is suitable for distance learning.

**Year:**

M.Sc. (Tech.) 2

**Period:**

2

**Teaching Language:**

English

**Teacher(s) in Charge:**

D.Sc. (Tech.) Juhamatti Korhonen

**Aims:**

Upon completion of the course the student will be able to:
1. describe the coupling mechanisms of electromagnetic interference in power electronics,
2. describe the most significant sources of electromagnetic emissions in power electronic systems,
3. provide suitable filter solutions for common-mode filtering, differential-mode filtering, du/dt filtering and harmonics filtering.

**Contents:**

Power electronics as an interference source, network harmonics, reflection phenomena of cables, conductive RF interference, interference radiation of power electronics, filtering techniques of conductive interference.

**Teaching Methods:**

14 h of lectures, 2st period. Moodle examination, weekly quizzes. Independent work 38 h. Online course.
Total workload 52 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

Yes

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, Moodle examination 70 %, weekly quizzes 30 %.

**Course Materials:**

To be announced in class.

**Prerequisites:**

Recommended: Basic knowledge of electromagnetism and electromagnetic fields.

**Places for exchange-students? (Yes, number/No):**

15–

**Places for Open University Students?(Yes, number/No):**

max 10

**SaDDoEm: Design of Electrical Machines, 24 cr**

**Validity:** 01.08.2017 -
**Form of study:**
**Type:** Study module
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F

No course descriptions.

*Elective module 24 ECTS cr.*

**BL20A0100: Thermal Design of an Electric Device, 3 cr**

**Validity:** 01.08.2007 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Janne Nerg

**Note:**

The course is suitable for distance learning.

**Year:**

M.Sc. (Tech.) 1

**Period:**

3

**Teaching Language:**

Finnish

**Teacher(s) in Charge:**

Associate professor, D.Sc. (Tech.) Janne Nerg

**Aims:**

Upon completion of the course the student will be able to 1. perform thermal design of a simple electronic device, 2. describe the heat transfer mechanisms and 3. analytically calculate temperature distribution of an electronic device.

**Contents:**

Heat transfer mechanisms, cooling methods of electronic devices, the effect of the operation temperature on the performance of an electronic device, thermal resistance networks, numerical calculation methods in thermal engineering.

**Teaching Methods:**

Lectures 14 h, exercises 14 h, home assignments, 3rd period. Examination or continuous assesment. Course is suitable for distance learning. Total workload 78 h.

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0–5, examination or continuous assesment 100 %.

**Course Materials:**

Course material is found from Moodle.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

max 5

### BL30A0400: Design of an Electrical Machine, 6 cr

**Validity:** 01.08.2007 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Juha Pyrhönen

**Year:**

M.Sc. (Tech.) 1

**Period:**

1

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, D.Sc. (Tech.) Juha Pyrhönen

**Aims:**

Upon completion of the course the student will be able to: 1. perform a basic design of a rotating electrical machine, 2. design the simplest winding arrangements and other components of the machine, 3. explain the torque production process in electrical machines, 4. calculate the main data (equivalent circuit parameters) of an electrical machine from machine geometric and winding designs, 5. List and apply the most important materials used in magnetic circuits and windings, 6. model the machine with an equivalent circuit, 7. compare machine designs with each other by using the per unit presentation of machines, 8. use phasor diagrams in the machine analysis, 9. discuss the problems of insulation systems and heat transfer.

**Contents:**

Electromagnetic principles used in machine design, the magnetic circuit of an electric machine, the windings of an electric machine, impacts of the structure of the electric motor on the motor characteristics, calculation of the parameters of an equivalent circuit from the dimensions of the machine (resistances, inductances), effective-value phasor diagrams for different machine types, principles of electric machine design, insulation materials and systems heat transfer.

**Teaching Methods:**

Lectures 24 h, tutorials 24 h, design assignment of an electric machine 48 h and other independent studies 57 h, exam 3 h 1st period.
Total workload 156 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, written examination 100 %. Satisfactorily completed assignment required.
Or: The course can be passed with the grade “Accepted” by satisfactory completion of the homework and the design assignment.

**Course Materials:**

Lecture materials in Moodle.
The course is based on suitable parts of Pyrhönen, Jokinen, Hrabovcova: Design of Rotating Electrical Machines

**Prerequisites:**

Students are recommended to have good knowledge in electromagnetism, completed BL30A0000 Electric Circuits, BL10A0100 Basics of Electric Engineering.

**Places for exchange-students? (Yes, number/No):**

15–

**Places for Open University Students?(Yes, number/No):**

max 5

### BL30A0800: Electromagnetic Components, 3 cr

**Validity:** 01.08.2007 -

**Form of study:** Basic studies

**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Janne Nerg

**Note:**

The course is suitable for distance learning.

**Year:**

M.Sc. (Tech.) 1

**Period:**

1

**Teaching Language:**

Finnish

**Teacher(s) in Charge:**

Associate professor, D.Sc. (Tech.) Janne Nerg

**Aims:**

Upon completion of the course the student will be able to: 1. design simple transformers and inductors, 2. name and describe magnetic core materials, 3. describe the different loss mechanisms, 4. explain the non-linearities of inductors and transformers at different frequencies, 5. minimise the transformer leakage inductance.

**Contents:**

Faraday’s induction law, Ampère’s law, operation principle of a transformer and an inductor, non-linearities of electromagnetic components, magnetic materials, iron losses and copper losses.

**Teaching Methods:**

14 h of lectures, 14 h of tutorials, 1st period. Home assignments. Examination or continuous assesment. The course is suitable for distance learning.
Total workload 78 h.

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, examination or continuous assesment 100 %.

**Course Materials:**

Course material is found from Moodle.

**Prerequisites:**

BL30A0300 Electromagnetism attended.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

max 5

**BL30A1001: Electrical Drives, 8 cr**

**Validity:** 01.08.2010 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Juha Pyrhönen

**Note:**

The first part (2nd period) will be studied in collaboration with BL30A1020 Electrical Drives, Compact. Common lectures, exercises and homework. The student may participate either in “Electrical Drives, Compact” or “Electrical Drives”, not in both of them.

**Year:**

M.Sc. (Tech.) 1

**Period:**

2-3

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, D.Sc. (Tech.) Juha Pyrhönen

**Aims:**

Upon completion of the course the student will be able to: 1. understand the role of electrical drives, 2. understand different torque producing principles in different machines, 3. model and simulate a DC motor drive, 4. describe the principles of scalar, vector and direct torque control of rotating field machines, 5. define and understand the functioning of the most important power electronic converters, 6. discuss the principles of PWM in general, space vector modulation and DTC, 7. model the behaviour of permanent magnet synchronous machine by using vector equivalent circuits and vector diagrams, 8. understand synchronous machine control in details, 9. understand synchronous reluctance machine control in details, 10. understand the role of induction machine and its control in details, 11. know the switched reluctance machine control principles, 12. discuss the adverse effects of PWM systems on motor behaviour and the wave nature of the motor cable. Mastering the course material well gives the student comprehensive understanding of the basics of electrical drives and wide possibilities to work in the field. This is the course for drives professionals.

**Contents:**

Theory of electric motor drives, operation and vector equivalent circuits. Synchronous machine drives, asynchronous machine drives, synchronous reluctance machine drives, permanent magnet synchronous machine drives, switched reluctance motor drives. Torque production in different machines. Power electronic converters suitable for motor and generator drives. Scalar control, vector control, direct flux linkage control and direct torque control (DTC). Motor cable wave nature, bearing currents. Applying the principles for practical electrical machine types.

**Teaching Methods:**

Lectures 24 h, tutorials 24 h, 2nd period. Lectures 24 h, tutorials 24 h, 3rd period. Independent study including homework tasks 109 h. Examination 3 h.
Total workload 208 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

Yes

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, written examination 100 %.
OR Pass/fail via good enough independent homework.

**Course Materials:**

Lecture material in Moodle.
The course is based on the book: Pyrhönen, Hrabovcova, Semken: “Electrical Machine Drives Control: An Introduction”, published by John Wiley et Sons 2016

**Prerequisites:**

The students are recommended to have completed the courses BL30A0000 Electric Circuits, BL10A0100 Basics of Electric Engineering, BL30A0200 Laboratory Course in Electrical Engineering, BL30A0500 Introduction to Electrical Drives and BL30A0800 Electromagnetic Components and to have attended the course BL30A0400 Design of an Electrical Machine.

**Places for exchange-students? (Yes, number/No):**

15–

**Places for Open University Students?(Yes, number/No):**

max 5

### BL30A1200: Numerical Methods in Electromagnetism, 4 cr

**Validity:** 01.08.2007 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Janne Nerg

**Year:**

M.Sc. (Tech.) 2

**Period:**

3

**Teaching Language:**

English

**Teacher(s) in Charge:**

Associate professor, D.Sc. (Tech.) Janne Nerg

**Aims:**

Upon completion of the course the student will be able to model and analyse electrical machines using commercial finite element based calculation software.

**Contents:**

The fundamentals of the element method, boundary conditions, modelling of materials, post-processing of results. Iron loss models. Eddy current problems, utilisation of circuit model in calculation.

**Teaching Methods:**

28 h of supervised tutorials. 3rd period. Self study: assignment and report 76 h.
Total workload 104 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

Course requirements: participation in tutorials and a satisfactorily completed assignment. 0-5, assignment 100 %.

**Course Materials:**

Course material in Moodle.

**Prerequisites:**

BL30A0500 Introduction to Electrical Drives and BL30A0400 Design of an Electrical Machine.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

max 5

**SaDECS: Electric Conversion Systems, 24 cr**

**Validity:** 01.08.2017 -
**Form of study:**
**Type:** Study module
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F

No course descriptions.

*Elective module 20 ECTS cr.*

**BL30A0600: Power Electronics, 6 cr**

**Validity:** 01.08.2007 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Lasse Laurila

**Note:**

The course is suitable for distance learning.
Course has examination in Examination schedule, but it is not traditional paper exam. The exam will be done with computer.

**Year:**

M.Sc. (Tech.) 1

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Associate professor, D.Sc. (Tech.) Lasse Laurila

**Aims:**

Upon completion of the course the student will be able to: 1. demonstrate good general knowledge of the different basic main circuits in modern power electronics, 2. describe the features and functions of different rectifiers, switch-mode converters and inverters, 3. calculate and simulate typical design tasks of the aforementioned circuits, 4. describe the joint operation of static converters and loads as well as the network interferences caused by converters and alternatives to reduce these interferences.

**Contents:**

Operation of the main circuits of different power converters: rectifiers (single and three-phase), DC-DC switch mode converters and power supplies (buck, boost, buck-boost, flyback, forward), inverters (single and three-phase), resonance converters (ZVS, ZCS). Characteristics and operation. Pulse width modulation (PWM). Harmonic components. Simulation of power electronic circuits (simulation tools used: PSpice and Matlab/Simulink, calculations on Mathcad, Excel). Possible extra assignments to gather extra points to the exam.

**Teaching Methods:**

Combined lectures and tutorials, 28 h, 1st period. Combined lectures and tutorials, 28 h, 2nd period. Moodle-examination, 3 h. Independent study 97 h. The course is suitable for distance learning.
Total workload 156 h.

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

Yes

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, examination 100 %. 75 % of tutorial tasks passed or 75 % active presence in tutorials. Possible extra assignments to gather extra points to the exam.

**Course Materials:**

Mohan, Undeland, Robbins: Power Electronics, converters, applications, and design. Chapters 1 to 18.
Course material in Moodle.

**Prerequisites:**

Recommended: BL30A0000 Electric Circuits. Integration and derivation (esp. sine and cosine functions).
FFT. Laplace transforms. Basic software skills with Excel, Word.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

max 5

### BL30A1020: Electrical Drives, Compact, 4 cr

**Validity:** 01.08.2017 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Juha Pyrhönen

**Note:**

The course has common lectures exercises and homework with the first part of the course BL30A1001 Electrical Drives.
The student may participate either in “Electrical Drives, Compact” or “Electrical Drives”, not in both of them.

**Year:**

M.Sc. (Tech.) 1

**Period:**

2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, D.Sc. (Tech.) Juha Pyrhönen

**Aims:**

Upon completion of the course the student will be able to: 1. understand the role of electrical drives, 2. understand different torque producing principles in different machines, 3. model and simulate a DC motor drive, 4. describe the principles of scalar, vector and direct torque control of rotating field machines, 5. define the most important power electronic converters, 6. discuss the principles of PWM, space vector modulation and DTC. 7. model the behaviour of permanent magnet synchronous machine by using vector equivalent circuits and vector diagrams.

**Contents:**

Theory of electric motor drives, operation and vector equivalent circuits. Torque production in different machines. Power electronic converters suitable for motor and generator drives. Scalar control, vector control, direct flux linkage control and direct torque control (DTC). Permanent magnet synchronous machine drives.

**Teaching Methods:**

Common lectures 24 h, tutorials 24 h, 2nd period. Independent study including homework 56 h. Total workload 104 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

Pass/fail. The course can be passed with via good enough independent homework.

**Course Materials:**

Lecture material in Moodle
The course is based on chapters 1-7 and 9 of the book: Pyrhönen, Hrabovcova, Semken, “Electrical Machine Drives Control: An Introduction”, published by John Wiley et Sons 2016

**Prerequisites:**

The students are recommended to have completed the courses BL30A0000 Electric Circuits, BL10A0100 Basics of Electric Engineering, BL30A0200 Laboratory Course in Electrical Engineering, BL30A0500 Introduction to Electrical Drives and BL30A0800 Electromagnetic Components and to have attended the course BL30A0400 Design of an Electrical Machine.

**Places for exchange-students? (Yes, number/No):**

15–

**Places for Open University Students?(Yes, number/No):**

max 5

### BL40A2401: Electrical Engineering in Wind and Solar Systems, 6 cr

**Validity:** 01.08.2013 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Olli Pyrhönen

**Note:**

The course is suitable for distance learning.

**Year:**

M.Sc. (Tech.) 1

**Period:**

3-4

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, D.Sc. (Tech.) Olli Pyrhönen

**Aims:**

Upon completion of the course the student can: 1. Describe the functional principle of wind or solar power plant 2. describe and identify electrotechnical components and system layouts in wind and solar power plants, 3. dimension the electrotechnical components in wind /solar power plants, 4. describe and analyse the control systems of wind/solar power plants, 5. describe and analyse the grid connection requirements of wind/solar power plants, 6. Describe and analyse the interaction between the grid and wind/solar power plant in different abnormal situations.

**Contents:**

Drive train technologies in wind power systems, Permanent magnet synchronous generator drive train, double-fed induction generator drive train, electric conversion in PV solar power, system topologies and power electronics solutions in small and utility scale PV solar plants. Control of a wind power plant, control of a solar power plant, technical requirements in grid connection, voltage and reactive power control in wind/solar power plants, electrical protection of wind/solar power plants. Grid codes, other international regulations and standards in wind and solar power systems. Introduction to grid connection modelling software.

**Teaching Methods:**

Lectures 28 h, exercises 14 h, demolectures 6 h, 4-6 h, assignment 62 h, independent working 37 h, examination 3h. Total workload 156 h. The course is suitable for distant learning. In distant learning, exersices are replaced by homeworks.
Total workload 156 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

Yes

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, examination 50 %, homeworks 25 %,  assignment 25 %

**Course Materials:**

Material handed out in class.

**Prerequisites:**

Previous knowledge of electrical engineering required. Basics of electrical machines and/or transmission of electricity recommended.

**Number of exercise groups where enrollment is in WebOodi (Number/Leave empty):**

1

**Places for exchange-students? (Yes, number/No):**

max 10

**Places for Open University Students?(Yes, number/No):**

No

### BL40A2910: Electric Energy Conversion Systems, 4 cr

**Validity:** 01.08.2017 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Olli Pyrhönen, Pasi Peltoniemi

**Year:**

M.Sc. (Tech.) 2

**Period:**

1

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, D.Sc. (Tech.) Olli Pyrhönen

**Aims:**

The student knows the most relevant electrical power conversion solutions in industrial and power system applications. He/she get knowledge of system topologies, main components and control principles in the selected application fields. He/she is able to make basic system design, component selection and dimensioning according to application specifications.

**Contents:**

Marine vessel power system technology, system layout, components and control principles. Electric vehicle and hybrid work machine power system technology, components and control principles. Industrial drive applications, components and control principles. Electrochemical conversion system applications, components and control principles. Examples of different applications. Component selection and dimensioning. Examples of existing system solutions in different application fields.

**Teaching Methods:**

14 hours of lectures, 1st period. 6-7 h Visiting lectures from industry, 2nd period. Assignment 1st and 2nd period 40 h.

Written examination 3 h. Independent working 40 h.
Total workload 104 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

Yes

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5. Written examination (70%), assignment (30%).

**Course Materials:**

Lecture material.

**Prerequisites:**

Electrical Drives, Compact
Power Electronics
Säätötekniikan perusteet /Introduction to Control Engineering

**Places for exchange-students? (Yes, number/No):**

Yes, max 10

**Places for Open University Students?(Yes, number/No):**

No

**SaDSoEc: Solar Economy, 18 - 21 cr**

**Validity:** 01.08.2017 -
**Form of study:**
**Type:** Study module
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F

No course descriptions.

*Elective module 18-21 ECTS cr.*

**BL20A1300: Energy Resources, 6 cr**

**Validity:** 01.08.2014 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Michael Child, Christian Breyer

**Year:**

M.Sc. (Tech.) 1

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, D.Sc. (Tech.) Christian Breyer

**Aims:**

Upon completion of the course the student will be able to: 1. Identify the constraints and potentials of all relevant energy sources in a global context. 2. Describe all relevant energy conversion technologies on the basis of their energy resource. 3. Analyse the principal structure of future energy systems on the basis of energy resource characteristics. 4. Describe the special relevance of wind energy and solar energy in the ongoing energy transformation.

**Contents:**

The course provides an overview on the availability of energy resources and related emissions and techno-economic maturity of related energy conversion technologies, which induces a fundamental structure for the future energy system and the related energy transformation pathway. The course comprises the main energy resources for the current and future energy system: crude oil,natural gas, coal, uranium, hydro power, bioenergy, solar energy, wind energy, geothermal energy, and ocean energy. These energy resources have different theoretical, technical and economic potentials as well as geographic variations in availability. The resources also differ considerably in the impact of the emissions related to the respective energy conversion technologies being relevant for the degree of sustainability. A broad variety of energy conversion technologies at different levels of maturity are used for utilizing the resources.

**Teaching Methods:**

Lectures 14 h, exercises 14 h, 1st period. Lectures 14 h,exercises 14 h, 2nd period. Examination 3h. Independent study 97 h.
Total workload 156 h.

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, examination 100%.

**Course Materials:**

Material handed out in class and made available on Moodle.

**Places for exchange-students? (Yes, number/No):**

15–

**Places for Open University Students?(Yes, number/No):**

max 5

### BL20A1400: Renewable Energy Technology, 6 cr

**Validity:** 01.08.2015 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Christian Breyer, Michael Child

**Year:**

M.Sc. (Tech.) 1

**Period:**

3-4

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, D.Sc. (Tech.) Christian Breyer

**Aims:**

Upon completion of the course the student will be able to: 1. Identify the major renewable energy (RE) conversion technologies, mainly converting resources to electricity. 2. Describe the major characteristics of the technologies, in particular applications, efficiency, economics, industrial scale and future prospects. 3. Analyse the need for storage technologies and their different fields of application based on their key technical and economic features.

**Contents:**

The course is focused on the conversion of the resources to electricity. The RE technologies discussed in the course are: wind turbines, solar photovoltaics, solar thermal electricity generation and hydro powerplants. The storage technologies covered comprise a general overview and in particular include battery storage, pumped hydro storage and power-to-gas technologies. All technologies are classified with respect to their applications, efficiency, maturity, economics, industrial scaling and expected relevance for the ongoing energy transformation.

**Teaching Methods:**

3$^{rd}$ period lectures 14 h, exercises 14 h. 4$^{th}$period lectures 14 h, exercises 14 h, examination 3 h. Independent study 97 h.
Total workload 156 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, examination 100 %

**Course Materials:**

Material handed out in class and made available on Moodle.

**Places for exchange-students? (Yes, number/No):**

15–

**Places for Open University Students?(Yes, number/No):**

max 5

### BL20A1500: Energy Scenarios, 6 cr

**Validity:** 01.08.2015 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Christian Breyer, Michael Child

**Year:**

M.Sc. (Tech.) 2

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, D.Sc. (Tech.) Christian Breyer

**Aims:**

Upon completion of the course the student will be able to: 1. Describe the sustainability requirements of future energy systems as the major guard rail for the energy transformation. 2. Analyse energy transformation scenarios and identify the key technologies and setups for sustainable energy progress. 3. Describe the energy transformation in all sectors, the major technologies, the required transformation period and entire system cost optimization. 4. Describe the special role of power technologies for the energy transformation. 5. Recognize the difference between standard levelized cost ofenergy and total societal cost of energy.

**Contents:**

The course comprises the key elements of energy scenarios: demand, supply, cost, constraints. Energy demand is an aggregate of power, heat, cooling, mobility, agriculture and industrial energy needs. The demand has tobe matched with supply of energy fulfilling sustainability criteria, safety requirements and societal acceptance for the least cost. A complete set of demand curves, technical characteristics of all major technologies, current and projected technology costs and emission factors are taken into account for sustainable energy transformation pathway formulation. The special relevance ofwind energy and solar photovoltaics, the increasing relevance of power technologies,the role of storage technologies and the necessity of societal cost of energy are discussed in detail. Real scenarios for Finland, Europe and the World used as references.

**Teaching Methods:**

1st period lectures 14 h, exercises 14 h. 2ndperiod lectures 14 h, exercises 14 h, presentation/oral examination 1 h. Independent study 99 h. Total workload 156 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, presentation/oral examination 100 %

**Course Materials:**

Material handed out in class and made available on Moodle.

**Prerequisites:**

BL20A1300 Energy Resources and BL20A1400 Renewable Energy Technology (at least one of the two courses)

**Places for exchange-students? (Yes, number/No):**

max 15

**Places for Open University Students?(Yes, number/No):**

max 5

*LUT Summer School course, optional.*

**BL10A8400SS: Solar Economy and Smart Grids, 3 cr**

**Validity:** 01.06.2014 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Jarmo Partanen, Satu Viljainen, Olli Pyrhönen, Christian Breyer

**Year:**

M.Sc. (Tech.) 1–2

**Period:**

INT. Summer School

**LUT Summer School time:**

6. – 10.8.2018

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, D.Sc. (Tech.) Christian Breyer

**Aims:**

After having passed this course the student is able to:
- understand the basic processes of solar economy and Smart Grids
- recognize the key properties of global climate challenges, solar economy, electricity market models, wind and solar power technologies, energy storage technologies and smart grid concept
- recognize the most important aspects, chances and challenges of transformation from existing energy systems to sustainable energy systems.

**Contents:**

During the course the student will become familiar with the properties and application areas of:
- Climate change
- Solar economy
- Wind power technology
- Solar power technology
- Energy Storage Technologies
- New electricity market
- Demand response
- Smart Grid concept.

**Teaching Methods:**

- Introductory lectures and exercises 24 h
- Team work and a limited project work 20 h
- Presentations of the results of the team work/ project work 8 h
- Independent work is needed 26 h.

Total workload 78 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

Final grade 0 –5, project work/presentation

**Course Materials:**

Lecture notes and other materials distributed during the course by email.

**Prerequisites:**

Previous studies either in electrical engineering, environmental engineering or energy engineering are recommended.

**Places for exchange-students? (Yes, number/No):**

15–

**Places for Open University Students?(Yes, number/No):**

max 5

### SaDCaA: Control and Automation, 22 cr

**Validity:** 01.08.2017 -
**Form of study:**
**Type:** Study module
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F

No course descriptions.

*Elective module 22 ECTS cr.*

#### BL40A0810: Digital Signal Processing II, 4 cr

**Validity:** 01.08.2017 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Engineering Science
**Grading:** Study modules 0-5,P/F
**Teachers:** Antti Kosonen, Tuomo Lindh

**Year:**

M.Sc. (Tech.) 1

**Period:**

3-4

**Teaching Language:**

English

**Teacher(s) in Charge:**

Associate Professor, D.Sc. Antti Kosonen

**Aims:**

Upon completion of the course the student will be able to: 1. describe the practical implementation of digital filters, 2. describe the finite word length effects on the frequency response and operation of a filter, 3. in order to minimize these effects, transform the direct-form implementations into a more beneficial format with respect to the finite word length effects and do the required scaling, 4. describe the representations of fixed and floating point numbers, 5. design FIR and IIR filters with the ready-made software and describe the basics of design methods, 6. know applications of optimal and adaptive filters, 7. implement median filters.

**Contents:**

The finite word length effects and elimination of these effects. Alternative structures for discrete-time systems and their programming implementation. Computer-aided design of digital filters. Decimation and interpolation. Median filters. Optimal and adaptive filters.

**Teaching Methods:**

14 h of lectures and 14 h of tutorials, 1st period.14 h of lectures, 14 h of tutorials, 30 h of assignment with seminar, 2nd period. Written examination. Independent study 18 h.
Total workload 104 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

Examination 60%, assignment 40%.

**Course Materials:**

Proakis, J.G.and Manolakis, D.G.: Digital Signal Processing, Principles,Algorithms, and Applications.
Lecture slides.
Luukko, J.: Digitaalinen suodatus (luentomoniste)

**Prerequisites:**

BL40A0401 Signaalien digitaalinen käsittely I (Digital Signal Processing I) or corresponding knowledge.

**Places for exchange-students? (Yes, number/No):**

max 10

**Places for Open University Students?(Yes, number/No):**

max 15

### BL40A1202: Digital Control Design, 6 cr

**Validity:** 01.08.2017 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Olli Pyrhönen, Pasi Peltoniemi, Rafal Jastrzebski

**Year:**

M.Sc. (Tech.) 1

**Period:**

1-2

**Teaching Language:**

Finnish and English

**Teacher(s) in Charge:**

Professor Olli Pyrhönen

**Aims:**

Upon completion of the course students  are able to design and implement a digital control system for industrial application independently. The necessary skills are dynamic plant modeling, system design, control synthesis, system simulation and digital controller implementation in an industrial control platform.

**Contents:**

The teaching approach on this course is practical control design and implementation for different applications. The first half of the course introduces design of advanced control methods for different application. The application topics may change yearly. The following topics are included, plant modelling, different state-space and transfer functions algorithms for SISO and MIMO systems, digital controller synthesis, system simulation, controller programming and testing. In the second half of the course every student will design, program and test a controller using an industrial controller platform and a laboratory equipments.

**Teaching Methods:**

28 h interactive lectures in computer class room, 1. period, 14 h control system development project tutorial lectures in computer class room, laboratory working 6 h, exam 3 h, independent studies.
Total workload 156 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

Yes

**Examination in Exam (Yes/No):**

No

**Assessment:**

Examination 60%, control system design project 40%.

**Course Materials:**

Lecture script and handout, more detailed material in the text books:
Franklin G.F., Powell J.D., Workman M.L., Digital Control of Dynamic Systems, Addison-Wesley, 1998,
Kuo B., Digital Control Systems, 2nd ed., Oxford University Press, 1992,
Åström K.J., Wittenmark B., Computer Controlled Systems, 3rd ed., Prentice Hall, 1997, 557 p.

**Prerequisites:**

BL40A0200 Säätötekniikan perusteet A or BL40A0300 - Säätötekniikan perusteet B
BL40A0501 - Digitaalisäädön perusteet

**Places for exchange-students? (Yes, number/No):**

max 10

**Places for Open University Students?(Yes, number/No):**

No

**BL40A2700: System Engineering Project Work, 6 cr**

**Validity:** 01.08.2013 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Olli Pyrhönen, Jero Ahola, Jan-Henri Montonen, Tuomo Lindh

**Year:**

M.Sc. (Tech.) 2

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Associate professor. D.Sc. (Tech.) Tuomo Lindh, professor, D.Sc. (Tech.) Olli Pyrhönen, professor, D. Sc. (Tech.) Jero Ahola

**Aims:**

Upon completion of the course the student is prepared to work in a R&D team as a system engineer. The student is able to manage the project scheduling and project roles, and share responibilities among group members. The student can produce a tecnical documentation.

**Contents:**

The students will analyse and design a selected electrical energy conversion system in the field of industrial electrical drives, renewable energy conversion or motion control system. The topics are linked to an on-going research project or industrial co-operation in the above-mentioned fields. The project work includes several partly alternative system engineering tasks, such as project planning, preliminary system design, dynamic modelling and simulation, component dimensioning, electrical dimensioning, control design, automation design, control software design and project documentation. The tasks are project dependent and will be defined in the project plan.
Introduction to a system engineering approach in technical projects. Project documentation, different tasks in project work, project planning and implementation, example projects, execution of system engineering tasks, project documentation and presentation. The main result of the project work is technical project documentation including an overall description and the results of agreed system engineering tasks.

**Teaching Methods:**

Introductory lecture, independent group working (3-5 students in one group), individual tasks within the group work, project group meetings with supervisors, writing project documentation, project presentation and demonstration. The project work topics will be defined in detail at the beginning of the course.
Total workload 156 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, Project work that includes management of the project, system design, problem solving, designs, documentation and presentation.
Also the project phases from setting the goals to the design, implementation and utilization are graded.

**Course Materials:**

Project related material.
Jürg Kuster, Eugen Huber, Robert Lippmann, Alphons Schmid, Emil Schneider, Urs Witschi,Roger Wüst. Project Management Handbook, ISBN 978-3-662-45373-5.

**Prerequisites:**

A majority of the M.Sc. (El. Eng.) studies should be completed before participation.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

This course has 1-5 places for open university students. More information on the web site for open university instructions.

### BL40A2810: Automation, 6 cr

**Validity:** 01.08.2017 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Tuomo Lindh, Jan-Henri Montonen

**Year:**

M.Sc. (Tech.) 1

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Associate professor, D.Sc. (Tech.) Tuomo Lindh

**Aims:**

Upon completion of the course the student will be able to: 1. apply automation and digital control theory to practical implementations, 2. use the analog and digital communication techniques applied to automation, 3. apply fieldbuses, 4. formulate a dynamic system model
of motor drives 5. Simulate servo motor driven mechatronic systems, 6. construct controllers and models of dynamic systems using IEC61131-3 and C programming languages, 7. select a proper controller structure, 8. work in a group solving automation and control problems.

**Contents:**

IEC61131-3 programming languages, Feedback devices, Automation hardware and software. Fieldbuses. Basics of servo drive dynamics, Utilizing Simulink models in PLC systems. C/C++ languages in PLC systems. HMI, OPC, IoT in automation. Introduction to safety in automation.

**Teaching Methods:**

Lectures 14 h, exercises 14 h, 1st period.
Lectures 14 h, exercises 14 h, 2nd period.
Independent study: project work 35 h, laboratory exercises 21h
preparation for examination 40 h, examination at Moodle 4 h.
Total workload 156 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

Yes

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, examination 40 %. Project work 60%.

**Course Materials:**

Presentation slides at Moodle.
Karl-Heinz John, Michael Tiegelkamp.IEC 61131-3: Programming Industrial Automation Systems.e-ISBN 978-3-642-12015-2.

**Prerequisites:**

Basics of programming.

**Places for exchange-students? (Yes, number/No):**

Yes, 10.

**Places for Open University Students?(Yes, number/No):**

This course has 1-10 places for open university students. More information on the web site for open university instructions.

**SaDEmSy: Embedded Systems, 24 cr**

**Validity:** 01.08.2017 -
**Form of study:**
**Type:** Study module
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F

No course descriptions.

*Elective module 24 ECTS cr.*

**BL40A0810: Digital Signal Processing II, 4 cr**

**Validity:** 01.08.2017 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Engineering Science
**Grading:** Study modules 0-5,P/F
**Teachers:** Antti Kosonen, Tuomo Lindh

**Year:**

M.Sc. (Tech.) 1

**Period:**

3-4

**Teaching Language:**

English

**Teacher(s) in Charge:**

Associate Professor, D.Sc. Antti Kosonen

**Aims:**

Upon completion of the course the student will be able to: 1. describe the practical implementation of digital filters, 2. describe the finite word length effects on the frequency response and operation of a filter, 3. in order to minimize these effects, transform the direct-form implementations into a more beneficial format with respect to the finite word length effects and do the required scaling, 4. describe the representations of fixed and floating point numbers, 5. design FIR and IIR filters with the ready-made software and describe the basics of design methods, 6. know applications of optimal and adaptive filters, 7. implement median filters.

**Contents:**

The finite word length effects and elimination of these effects. Alternative structures for discrete-time systems and their programming implementation. Computer-aided design of digital filters. Decimation and interpolation. Median filters. Optimal and adaptive filters.

**Teaching Methods:**

14 h of lectures and 14 h of tutorials, 1st period.14 h of lectures, 14 h of tutorials, 30 h of assignment with seminar, 2nd period. Written examination. Independent study 18 h.
Total workload 104 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

Examination 60%, assignment 40%.

**Course Materials:**

Proakis, J.G.and Manolakis, D.G.: Digital Signal Processing, Principles,Algorithms, and Applications.
Lecture slides.
Luukko, J.: Digitaalinen suodatus (luentomoniste)

**Prerequisites:**

BL40A0401 Signaalien digitaalinen käsittely I (Digital Signal Processing I) or corresponding knowledge.

**Places for exchange-students? (Yes, number/No):**

max 10

**Places for Open University Students?(Yes, number/No):**

max 15

### BL40A1101: Embedded System Programming, 5 cr

**Validity:** 01.08.2017 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Jouni Vuojolainen, Tuomo Lindh, Teemu Sillanpää

**Year:**

M.Sc. (Tech.) 1

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Associate professor, D.Sc. (Tech.) Tuomo Lindh

**Aims:**

Upon completion of the course the student will be able to: 1. apply C language and its structures to embedded system programming, 2. form complex data types such as structures, unions and buffers and use these in order to maintain information of different entities (e.g. processing units), 3. control the registers of a micro controller using C-language, 4. use different PUs of a micro controller, 5. Take into use a real time operation system.

**Contents:**

Design tools, C-language in embedded system programming, utilization of a micro controller environment (registers, timers, buses, A/D conversion etc.). Typical data structures, typical program structures in real-time applications.

**Teaching Methods:**

14 h of lectures, 14 h of tutorials, 1st period. 14 h of lectures, 14 h of tutorials, 2nd period. Assignment. Written examination.
Total workload 130 h.

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, assignment 1 50 %, examination 50 %.

**Course Materials:**

Wolf, W.: Computers as components: principles of embedded computing system design. Lecture notes.

**Prerequisites:**

Basics of C language.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

This course has 1-5 places for open university students. More information on the web site for open university instructions.

### BL40A1601: Embedded System Design, 6 cr

**Validity:** 01.08.2013 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Jero Ahola, Juhamatti Korhonen

**Year:**

M.Sc. (Tech.) 1

**Period:**

3-4

**Teaching Language:**

English

**Teacher(s) in Charge:**

D.Sc. (Tech.) Juhamatti Korhonen

**Aims:**

Upon completion of the course the student will be able to program with VHDL hardware design language and design and implement digital systems by using programmable logic circuits.

**Contents:**

Circuit design of digital electronics with programmable logic circuits. Principles of digital circuit design, system level synthesis, hardware design languages.

**Teaching Methods:**

Lectures 14 h, exercises, 14 h, 3rd period. Lectures 14 h, exercises, 14 h, assignment, 4th period. Examination.
Total workload 156 h.

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, examination 25 %, assignment 1 25 %, assignment 2 50 %.

**Course Materials:**

To be announced in class.

**Prerequisites:**

Basics of digital design and digital electronics, basics of programming.

**Places for exchange-students? (Yes, number/No):**

Yes, 15

**Places for Open University Students?(Yes, number/No):**

Max. 15

### BL40A1740: Digital Electronics, 3 cr

**Validity:** 01.08.2017 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Jero Ahola, Tero Ahonen

**Year:**

M.Sc. (Tech.) 1

**Period:**

2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Antti Pinomaa, D.Sc. (Tech.), Post-doctoral researcher

**Aims:**

After the completion of course, the student is able to design, implement and simulate digital systems based on sequential logic. He/she is able to describe the functionality and implementation of basic sequential logic circuits, registries, memories, programmable logic circuits. In addition, the student is able to understand how digital systems are implemented with electronics and what physical limitations are involved.

**Contents:**

Sequential logic, components based on sequential logic, registries, memories, programmable logic circuits, design, simulation and implementation of digital systems, design of algorithmic state machines.

**Teaching Methods:**

Lectures 18 h, exercises 12 h, individual weekly assignments, independent study 48 h.
Total workload 78 h.

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, exam 100%. 70% of weekly assignments satisfactorily passed.

**Course Materials:**

Lecture material in Moodle.
Additionally, it is recommended to follow the book Floyd, Digital Fundamentals to the appropriate extent.

**Prerequisites:**

BL40A1730 Digitaalitekniikka (Digital technology)
Basics of digital technology (Boolean algebra, combinatorial logic systems)

**Places for exchange-students? (Yes, number/No):**

max 15

**Places for Open University Students?(Yes, number/No):**

max 15

### BL40A2700: System Engineering Project Work, 6 cr

**Validity:** 01.08.2013 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Olli Pyrhönen, Jero Ahola, Jan-Henri Montonen, Tuomo Lindh

**Year:**

M.Sc. (Tech.) 2

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Associate professor. D.Sc. (Tech.) Tuomo Lindh, professor, D.Sc. (Tech.) Olli Pyrhönen, professor, D. Sc. (Tech.) Jero Ahola

**Aims:**

Upon completion of the course the student is prepared to work in a R&D team as a system engineer. The student is able to manage the project scheduling and project roles, and share responibilities among group members. The student can produce a tecnical documentation.

**Contents:**

The students will analyse and design a selected electrical energy conversion system in the field of industrial electrical drives, renewable energy conversion or motion control system. The topics are linked to an on-going research project or industrial co-operation in the above-mentioned fields. The project work includes several partly alternative system engineering tasks, such as project planning, preliminary system design, dynamic modelling and simulation, component dimensioning, electrical dimensioning, control design, automation design, control software design and project documentation. The tasks are project dependent and will be defined in the project plan.
Introduction to a system engineering approach in technical projects. Project documentation, different tasks in project work, project planning and implementation, example projects, execution of system engineering tasks, project documentation and presentation. The main result of the project work is technical project documentation including an overall description and the results of agreed system engineering tasks.

**Teaching Methods:**

Introductory lecture, independent group working (3-5 students in one group), individual tasks within the group work, project group meetings with supervisors, writing project documentation, project presentation and demonstration. The project work topics will be defined in detail at the beginning of the course.
Total workload 156 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, Project work that includes management of the project, system design, problem solving, designs, documentation and presentation.
Also the project phases from setting the goals to the design, implementation and utilization are graded.

**Course Materials:**

Project related material.
Jürg Kuster, Eugen Huber, Robert Lippmann, Alphons Schmid, Emil Schneider, Urs Witschi,Roger Wüst. Project Management Handbook, ISBN 978-3-662-45373-5.

**Prerequisites:**

A majority of the M.Sc. (El. Eng.) studies should be completed before participation.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

This course has 1-5 places for open university students. More information on the web site for open university instructions.

**SaDMI: Microelectronics, 20 cr**

**Validity:** 01.08.2014 -
**Form of study:** Major studies
**Type:** Study module
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F

No course descriptions.

*Elective module 20 ECTS cr.*

**BL50A1300: Advanced Course in Electronics, 6 cr**

**Validity:** 01.08.2008 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Pertti Silventoinen, Jero Ahola

**Year:**

M.Sc. (Tech.) 1

**Period:**

3-4

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, D.Sc. (Tech.) Pertti Silventoinen

**Aims:**

The student prepares a seminar presentation on a new topic in electronics. Upon completion of the course the student will be able to demonstrate in-depth knowledge of a new topic in electronics.

**Contents:**

The course contents are subject related and will be specified during the introductory lectures.

**Teaching Methods:**

2 h of introductory lectures, 12 h of seminar presentations, 3rd period. 12 h of seminar presentations, 4th period. No written examination. Independent work 130 h.
Total workload 156 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Doctoral School course where enrollment is in WebOodi (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, seminar presentation. Peer review. 100 %.

**Course Materials:**

The material will be specified in the introductory lecture.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

max 5

### BM30A1600: Microelectronics, 6 cr

**Validity:** 01.08.2008 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Engineering Science
**Grading:** Study modules 0-5,P/F
**Teachers:** Erkki Lähderanta, Ekaterina Soboleva, Bernardo Barbiellini

**Year:**

M.Sc. (Tech.) 1

**Period:**

1

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, Ph.D. Bernardo Barbiellini
Junior Researcher, M.Sc.(Tech.) Ekaterina Soboleva

**Aims:**

Studentsget a good understanding of microelectronics basics and main integrated circuit(IC) components, students gain fluency to the most important variables and functions relatedto the IC components, and are able to apply their skills to analog IC design.

**Contents:**

Considering the basic components (PN junctions, metal-oxide-semiconductor, bipolar junction transistors, MOSFET, diodes, and amplifiers) of integrated circuit and their operation principles. Computation tasks and simulation to facilitate understanding.

**Teaching Methods:**

Lectures 28 h, exercises and tutorials 28 h, assignment 40 h, preparation for exam 60 h. Assignment and its presentation. Written examination.

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, examination 100 %. Satisfactorily completed assignment required.

**Course Materials:**

Roger T. Howe, Charles G. Sodini: Microelectronics An Integrated Approach.

**Prerequisites:**

Recommended BL40A1711 Johdanto digitaalielektroniikkaan and BL50A1400 Analogiaelektroniikka.

**Places for exchange-students? (Yes, number/No):**

max 5

**Places for Open University Students?(Yes, number/No):**

max 5

### BM30A1701: Physics of Semiconductor Devices, 6 cr

**Validity:** 01.08.2013 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Engineering Science

**Grading:** Study modules 0-5,P/F

**Teachers:** Tuure Tuuva

**Year:**

M.Sc. (Tech.) 2

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, Ph.D. Tuure Tuuva

**Aims:**

Student will acquire an in-depth knowledge of semiconductor diode, CCD, MOSFET, LED and photodiode and their operation.

**Contents:**

Structure, operation and physics of semiconductor devices.

**Teaching Methods:**

Special assignment 102 h, seminars 28 h, 1st-2nd period. Total workload 130 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

Pass/fail, seminar presentation 100 %.

**Course Materials:**

Sze, Physics of Semiconductor Devices.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

max 5

### BM30A2100: Microelectronics Processing Technology, 2 cr

**Validity:** 01.08.2009 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Engineering Science

**Grading:** Study modules 0-5,P/F

**Teachers:** Tuure Tuuva

**Year:**

M.Sc. (Tech.) 1

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, Ph.D. Tuure Tuuva

**Aims:**

To provide the student with a basic knowledge of microelectronics processing technology and components. Oxidation, diffusion and metallization.

**Contents:**

Purification of semiconductor materials. Growth of semiconductor crystals and wafer preparation. Epitaxial layers, diffusion, ion implantation, oxidation, etching and photolithography. Semiconductor manufacturing and development.

**Teaching Methods:**

Special assignment 52 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, seminar and/or written assignment 100 %.

**Course Materials:**

Plummer, J. D., Deal, M. D., Griffin, P. B., Silicon VLSI Technology: Fundamentals, Practice and Modeling.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

max 5

# Descriptions of courses and study modules not included in the degree structures

## KeSoD500: Advanced Chemistry, 20 - 25 cr

**Validity:** 01.08.2018 -
**Form of study:**
**Type:** Study module
**Unit:** LUT School of Engineering Science
**Grading:** Study modules 0-5,P/F

**Aims:**
After the completion of the minor in Advanced Chemistry the student
• has acquired a basic knowledge of the fundamental concepts of chemistry relevant to the major
• can apply his/her knowledge to select and to evaluate analytical or instrumental methodology in chemical analysis
• demonstrates sufficient knowledge to be applied in analytical work.

*Choose a min. of 20 ECTS*

### BJ02A1012: Concepts of Analytical and Inorganic Chemistry, 5 cr

**Validity:** 01.01.2018 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Engineering Science
**Grading:** Study modules 0-5,P/F
**Teachers:** Tiina Virtanen, Satu-Pia Reinikainen

**Note:**

The course is suitable for distance learning.

**Year:**

M.Sc. (Tech.) 1

**Period:**

4

**Teaching Language:**

English

**Teacher(s) in Charge:**

Satu-Pia Reinikainen, D.Sc. (Tech.), Professor
Tiina Virtanen, M.Sc., Junior Researcher

**Aims:**

By the end of the course, the student is expected to
- have acquired a basic knowledge of the fundamental concepts of inorganic chemistry relevant to the major
- be able to apply analytical methodology or the principles of selected instrumental methods in chemical analysis.

**Contents:**

This course contains two independent modules.1) Inorganic chemistry module is designed to prepare students for further study in inorganic chemistry or, more generally, employment in physical ormaterials science fields. The content include advanced concepts in structure, bonding, and chemical/physical properties of inorganic compounds, understanding of which is central to the study of all areas of chemistry. 2) Analytical chemistry module covers design, operational principles and application of modern instrumental methods used in chemical analysis via case studies. There are literature recommended for each module, and online interactive assignments. Students will work in small groups on the topic selected. The course is suitable for distance learning.

**Teaching Methods:**

Module 1: Assignments 20 h, discussions 10 h, peer feedback 10 h, Moodle quiz 5 h, online independent study 20 h, Module 2: Assignments 40 h, peer feedback and Moodle quiz 5 h, online independent study 20 h. Total workload 130 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

Numerical assessment (0-5), Module 1/2 50 %/50 % of total (assignments 60 %, online quizzes, peer feedback 40 %).

**Course Materials:**

Module 1: List of text books available in Moodle, Module 2: online material via Moodle.

**Places for exchange-students? (Yes, number/No):**

max 10

**Places for Open University Students?(Yes, number/No):**

max 10

### BJ02A1600: Biobased Materials and Advanced Organic Chemistry, 5 cr

**Validity:** 01.01.2018 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Engineering Science

**Grading:** Study modules 0-5,P/F

**Teachers:** Tiina Virtanen, Arto Pihlajamäki

**Year:**

M.Sc. (Tech.) 1

**Period:**

4

**Teaching Language:**

English

**Teacher(s) in Charge:**

Arto Pihlajamäki, D.Sc. (Tech.), Researcher/Teacher
Tiina Virtanen, M.Sc. (Tech.), Junior Researcher

**Aims:**

By the end of the course, a student is expected to:
- gain the basic chemical and technological understanding of the production of most important bioproducts from renewable resources
- be able to apply fundamental concepts of organic chemistry into application of biopolymers and their reactions.

**Contents:**

This course contains two modules. Biobased Materials module will introduce novel biomaterials and focus on properties of biobased polymers, their processing, reactions and applications. Advanced Organic Chemistry module gives extended knowledge in the structure and reactivity of organic biomolecules. There are lists of literature recommended for each module. Students will work in small groups on selected topics.

**Teaching Methods:**

Moodle lessons: Module 1 60 h, Module 2 60 h, 4th period. Quizzes and activities in Moodle 10 h. Total workload 130 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

Yes

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, Moodle exam, assignments and fulfilled activities in Moodle, project work reports in Modules 1 and 2.

**Course Materials:**

To be announced.

**Prerequisites:**

BJ01A1040 Orgaanisen kemian perusteet (Basic Organic Chemistry) or equivalent knowledge.

**Limitation for students? (Yes, number, priorities/Leave empty):**

Yes, 50, Students in Chemical Engineering M.Sc. programme.

**Places for exchange-students? (Yes, number/No):**

max 5

**Places for Open University Students?(Yes, number/No):**

max 5

### BJ02A1031: Solution Chemistry, 5 cr

**Validity:** 01.01.2018 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Engineering Science
**Grading:** Study modules 0-5,P/F

**Note:**

Starting from the academic year 2019-2020.

**Year:**

M.Sc. (Tech.) 2

**Period:**

1

**Teaching Language:**

English

**Teacher(s) in Charge:**

N.N.

**Aims:**

Upon completion of the module, the student has a deeper understanding on solution chemistry and the student is capable to evaluating the thermodynamic properties of electrolyte and nonelectrolyte solutions in the modern way.

**Contents:**

Ideal, ideally dilute, and real solutions. Experimental methods for measuring the activity and osmotic coefficients in solutions. The Debye-Hückel theory for electrolyte solutions. Pitzer equations for real electrolyte solutions. Concepts and equations needed in and associated with the thermodynamic formulation of the surface. Surfaces in electrolyte solutions and electrical double layer.

**Teaching Methods:**

Lectures 28 h, exercises 14 h, 1st period. Selfstudy 88 h. Total workload 130 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Doctoral School course where enrollment is in WebOodi (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

Yes

**Examination in Exam (Yes/No):**

No

**Assessment:**

Written examination 50%, Moodle assignments 50 %.

**Course Materials:**

Lecture notes and problems solution manuals based on the for example on the following textbooks:
Peter Atkins, Julio de Paula, and James Keeler. Atkins' Physical Chemistry, 11th Edition, 2017, Oxford University Press.
Kenneth Pitzer (edited), Activity Coefficients in Electrolyte Solutions, 2nd Edition, 2000, CRC Press, Boca Raton.

**Prerequisites:**

BJ01A3010 Kemiallinen termodynamiikka (Chemical Thermodynamics) or equivalent studies.

**Places for exchange-students? (Yes, number/No):**

max 10

**Places for Open University Students?(Yes, number/No):**

max 5

**BJ02A4070: Principles of Thermal Gas-Liquid Processes, 5 cr**

**Validity:** 01.01.2018 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Engineering Science

**Grading:** Study modules 0-5,P/F

**Year:**

M.Sc. (Tech.) 1

**Period:**

2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, D.Sc. (Tech.) Tuomas Koiranen

**Aims:**

Student understands distillation, evaporation and gas scrubbing technologies, including equipment structures and sizing principles. Student can design gas-liquid contactors by hand, is able to form mathematical calculation models, and can apply equations for computer simulation.

**Contents:**

Gas-liquid contactor theory, sizing principles and equations, calculation examples, computer exercises. Distillation, evaporation, gas scrubbing.

**Teaching Methods:**

Combined lectures and exercises 10 h, homeworks 72 h, self learning 48 h.
Total workload 130 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

Yes

**Examination in Exam (Yes/No):**

No

**Assessment:**

Examination grading scale 0-5. minimum 75 % of homeworks correct, returning to moodle.

**Course Materials:**

Course books:
Niket S. Kaisare, Computational Techniques for Process Simulation and Analysis Using MATLAB®, Taylor&Francis, 2017
Hussein K. Abdel-Aal, Chemical Engineering Primer with Computer Applications, Taylor&Francis, 2016
Felder, R.M., Elementary Principles of Chemical Processes, Wiley, 2004

**Prerequisites:**

BM20A1501 Numerical Methods or equivalent, BM20A4301 Introduction to Technical Computation or equivalent

**Places for exchange-students? (Yes, number/No):**

max 10

**Places for Open University Students?(Yes, number/No):**

max 5

**BJ03A1040: Advanced Materials in Adsorption and Ion Exchange, 5 cr**

**Validity:** 01.08.2016 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Engineering Science

**Grading:** Study modules 0-5,P/F

**Teachers:** Mika Sillanpää, Chaker Necibi

**Note:**

Suitable also for distance learning.

**Year:**

M.Sc. (Tech.) 1

**Period:**

2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, D.Sc. (Tech.) Mika Sillanpää
Post-doctoral researcher, D.Sc. (Tech.) Chaker Necibi

**Aims:**

By the end of the course, the student is expected to be able to: - describe the conventional and novel adsorption and ion-exchange materials - describe the conventional and novel applications of adsorption and ion-exchange - select a suitable adsorption/ion-exchange material for a particular purpose - understand the surface reactions in sorption processes - use theoretical models to describe adsorption kinetics, isotherms and thermodynamics - solve problems through PBL group work.

**Contents:**

Learning the types and properties of conventional and novel adsorption and ion-exchange materials and their applications in water treatment. Learning to evaluate the economic and environmental aspects of the production and use of different sorption materials. Learning the
surface reactions and theories behind the sorption phenomena. Both individual and group work including PBL-method, exercises and modeling calculations will be conducted.

**Teaching Methods:**

Lectures and exercises 20 h, PBL group work 12 h, 2nd period. Preparation for the exam, PBL work, independent workload 98 h.
Total workload 130 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

Yes

**Assessment:**

0-5, exam 50%, PBL group work 30% and homework 20%.

**Course Materials:**

Lecture notes. Moodle.

**Prerequisites:**

BJ03A1010 Introduction to Advanced Water Treatment

**Places for exchange-students? (Yes, number/No):**

max 10

**Places for Open University Students?(Yes, number/No):**

max 5

## KoDSaMate: Advanced Materials Engineering, 20 - 30 cr

**Validity:** 01.08.2016 -

**Form of study:**

**Type:** Study module

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Aims:**

After completing this minor subject the student will be able to:
- understand the influence of material selection to the product design
- structure hybrid materials from separate raw material sources
- have the readiness to understand the usability of nanomaterials and ceramics in processes and products
- apply various manufacturing methods to advanced materials processing and define concepts and entities related to high performance products
- ability to build up material selection route from end product and manufacturing methods to raw materials

*Obligatory Studies 25 ECTS cr*

### BK90C1900: Introduction to Materials Engineering, 4 cr

**Validity:** 01.08.2016 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Timo Kärki

**Year:**

M.Sc. (Tech.) 1-2

**Period:**

2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, D.Sc. (Tech.) , D.Sc. (Agr. & For.) Timo Kärki

**Aims:**

Aim of the course is to introduce possibilities of Material Engineering to students. Diverse possibilities of different materials is taken into consideration when optimizing the variable possibilities in Product Designing. After having completed this course, the student should be able to: understand the influence of material selection to the product design recognize the variable possibilities of different materials show creative and innovative expertise in the field of Materials Engineering.

**Contents:**

Basics of Materials Engineering and Product Design. Principles of materials selection and introduction to materials selection procedures. Choice of fabrication techniques including case studies related to different materials. Selecting polymers and composites as raw materials: structure, properties, processing characteristics and applications for the commercially important polymers including general classes of polymers: commodity, engineering and specialty thermoplastics, thermosetting resins and rubbers. Introduction to specific metals, alloys and minerals: metallurgy, properties, applications and potentialities of metals, alloys and minerals in a wide variety of engineering environments. Wood materials. Introduction to engineering ceramics. Properties and manufacturing of carbon based materials. Recycled Materials as a raw material source.

**Teaching Methods:**

Lectures 21 h. Independent study 63 h. Seminar 20 h. Total workload 104 h.

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, examination 70 %, seminar 30 %

**Course Materials:**

Course material in Moodle. Other literature to be announced during lectures.

**Prerequisites:**

-

**Places for exchange-students? (Yes, number/No):**

max 10

**Places for Open University Students?(Yes, number/No):**

max 10

### BK90C2000: Hybrid Materials, 3 cr

**Validity:** 01.08.2016 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Ossi Martikka

**Year:**

M.Sc. (Tech.) 1-2

**Period:**

2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Project Researcher, D.Sc. (Tech.) Ossi Martikka

**Aims:**

Organic–inorganic hybrids and composites have been playing a major role in research and society in recent years. This course aims to give the participants an understanding of the properties of the organic and inorganic components, preparation methods, characterisation techniques and also examples of functional hybrid materials. After having completed this course, the student should be able to: structure hybrid materials from separate raw material sources characterize hybrid materials with various testing methods can work in teams and solve problems related to hybrid materials

**Contents:**

Combinations of different materials. Various structures of hybrid materials. Properties of biopolymers and bionanomaterials. Different characterization methods: optical, morphological, surface, interfacial and mechanical characterization. Designing of Hybrid Materials. Performance of Hybrid Materials.

**Teaching Methods:**

Lectures 14 h. Exercises and individual guidance 20 h. Independent study 44 h. Total workload 78 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, oral examination in evaluation panel 50 %, exercises and seminar 50 %.

**Course Materials:**

Course material in Moodle. Other literature to be announced during lectures.

**Prerequisites:**

-

**Places for exchange-students? (Yes, number/No):**

max 10

**Places for Open University Students?(Yes, number/No):**

max 10

### BK90C2100: Functional Properties of Nanomaterials, 3 cr

**Validity:** 01.08.2016 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Irina Turku

**Year:**

M.Sc. (Tech.) 1-2

**Period:**

3

**Teaching Language:**

English

**Teacher(s) in Charge:**

D.Sc. (Tech.) Irina Turku

**Aims:**

Aim of the course is to get students familiar to different types of nanomaterials. Manufacturing processes of nanomaterials are also highlighted. After having completed this course, the student should be able to: understand the variety of nanomaterials and have the readiness to understand the usability of nanomaterials in processes and products, can work in
teams and solve problems.

**Contents:**

What is nanoscience about? Classification of nanomaterials. Nanomaterial structures, fundamentals and properties. Carbon based nanomaterials, liquid crystals properties and application, nanocellulose and 'smart" polymers. Analytical tools in nanoscience. Applications of nanomaterials. Synthesis of nanoscale materials. Bottom-up and top-down approaches. Safety of nanomaterials.

**Teaching Methods:**

14 h of lectures, 2 h of laboratory work, 14 h of tutorials, total workload 78 h, 3rd period

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

Yes

**Assessment:**

Numerical assessment, 0-5; Final grade will include: examination 60 %, essay 40 % and laboratory work (pass).

**Course Materials:**

M.F. Ashby et al. Nanomaterials, Nanotechnologies and Design, ELSIVIER Ltd, 2009; Lecture materials; Internet resources.

**Places for exchange-students? (Yes, number/No):**

15–

**Places for Open University Students?(Yes, number/No):**

max 10

### BK90C2200: Sustainable Manufacturing of Advanced Materials, 5 cr

**Validity:** 01.08.2016 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Marko Hyvärinen, Katriina Mielonen

**Year:**

M.Sc. (Tech.) 1-2

**Period:**

3

**Teaching Language:**

English

**Teacher(s) in Charge:**

Laboratory Engineer, D.Sc. (Tech.) Marko Hyvärinen

**Aims:**

Aim of the course is to demonstrate awareness of the range of modern manufacturing techniques for advanced materials and to select an appropriate manufacturing technique for a given component/use. After having completed this course, the student should be able to: apply various manufacturing methods to advanced materials processing define processing methods based on material selection can understand and identify possibilities of entrepreneurship in sustainable manufacturing.

**Contents:**

Introduction to processing technology and overview of manufacturing processes. Usable material forms: short fibers, non-woven mat, undirectional, bidirectional, multi-axial and braided weaves. Fundamentals of laminate construction: ply orientation, balance and symmetry. Manufacturing methods: wet layup, prepreg layup, filament winding, automated tape layup, automated fiber placement, resin infusion, press molding and pultrusion. Matrix resins: thermoset vs. thermoplastic polymers, process temperatures, service limits, storage requirements, shelf life limits and pot life/work life. Process equipment: oven, autoclave and platen press. Extrusion, injection moulding and moulding as manufacturing methods. Coating and laminations methods in packaging solutions. Future process developments.

**Teaching Methods:**

Lectures 28 h. Independent study 72 h. Seminar 30 h. Total workload 130 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

Yes

**Assessment:**

0-5, examination 70 %, seminar 30 %.

**Course Materials:**

Course material in Moodle. Other literature to be announced during lectures.

**Places for exchange-students? (Yes, number/No):**

max 10

**Places for Open University Students?(Yes, number/No):**

max 10

### BK90C2300: High Performance Products, 5 cr

**Validity:** 01.08.2016 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Timo Kärki

**Year:**

M.Sc. (Tech.) 1-2

**Period:**

4

**Teaching Language:**

English

**Teacher(s) in Charge:**

Laboratory Engineer, D.Sc. (Tech.) Marko Hyvärinen
Post-Doctoral Researcher, D.Sc. (Tech.) Sami-Seppo Ovaska

**Aims:**

Aim of the course is to highlight the developments in the design of energy systems, aircraft, cars, electronic equipment, constructions, packaging, etc., which depend critically upon the availability of novel materials. Of equal importance is an understanding of both advanced processing techniques, the latest computer based design procedures and environmental aspects essential for product commercialization from the concept phase. After having completed this course, the student should be able to: define concepts and entities related to high performance products have a good understanding about product range manufactured with various methods can solve real-life problems related to high performance products.

**Contents:**

Composite industry overview: applications for composites, history and current technologies. Health and safety and industry terminology in high performance products. Applications in energy systems, aeronautical industry, automotive industry, marine industry, construction industry and smart materials in packaging industry.

**Teaching Methods:**

Lectures 28 h. Independent study 72 h. Seminar 30 h. Total workload 130 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

Yes

**Assessment:**

0-5, examination 70 %, seminar 30 %.

**Course Materials:**

Course material in Moodle. Other literature to be announced during lectures.

**Places for exchange-students? (Yes, number/No):**

max 10

**Places for Open University Students?(Yes, number/No):**

max 10

### BK90C2400: Project course in Material Engineering, 5 cr

**Validity:** 01.08.2016 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Marko Hyvärinen

**Year:**

M.Sc. (Tech.) 1-2

**Period:**

4

**Teaching Language:**

English

**Teacher(s) in Charge:**

Laboratory Engineer, D.Sc. (Tech.) Marko Hyvärinen

**Aims:**

Aim of the course is to get the students familiar to the project type working in materials engineering. Typical project will start with selection of materials and manufacturing method for a certain end product. After having completed this course, the student should be able to: ability to build up material selection route from end product and manufacturing methods to raw materials ability to work in a project organisation in certain role can act and communicate in groups and networks.

**Contents:**

Projects are completed across the full spectrum of manufacturing, including energy systems, automotive, construction industry, packaging etc. Project titles are varied and cover areas of operational improvement, strategic decision-making and organizational management. Sub-areas for project can be following: material optimization, selection of manufacturing method, testing, production planning, scheduling and inventory optimization, capacity utilization, lead time reduction, quality improvement and control, new product development process, effective maintenance, energy usage, layout floor planning, inter-departmental effectiveness, feasibility study in to a new technology, market approval, sales, marketing and business strategy, new markets, products, company strategies, competitors and routes to market.

**Teaching Methods:**

Lectures 6 h, exercises and individual guidance 28 h, project work 96 h. Total workload 130 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, project work 70 %, exercises 30 %.

**Course Materials:**

Course material in Moodle. Other literature to be announced during lectures.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

max 10

## EnDSaBT: Bio-Energy Technology, 21 - 22 cr

**Validity:** 01.08.2013 -

**Form of study:**

**Type:** Study module

**Unit:** LUT School of Energy Systems

**Aims:**

After the completion of the minor in Bio-Energy Technology, the student:

• can analyse, design and select energy conversion processes for different applications, taking into account technological, economical, environmental and societal aspects

• understands what prerequisites various bio-fuels set for their utilization (processes and equipment).

*Obligatory studies of 13 ECTS.*

**BH50A1300: Maintenance Management, 4 cr**

**Validity:** 01.08.2007 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Esa Vakkilainen, Juha Kaikko

**Year:**

M.Sc. (Tech.) 2

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Docent, D.Sc. (Tech.) Juha Kaikko, Professor, D.Sc. (Tech.) Esa Vakkilainen

**Aims:**

Upon completion of the course the student willbe able to 1. identify the terminology used in maintenance management, 2. explain failure models, 3. utilize the concepts of reliability and availability, 4. explain maintenance strategies, 5. use methods to assess and control maintenance, and 6. describe how maintenance management is organized in power industry.

**Contents:**

Terminology. Engineering design: failure models, reliability and availability. Maintenance strategies. Maintenance assessment and control. Maintenance in power industry.

**Teaching Methods:**

1st period: 12 h of lectures and case exercises. 2nd period: 6 h of lectures and case exercises. Written assignment. Written examination. Independent study approximately: Written assignment 32 h. Preparation for the examination 14 h and the examination 3 h. Studying given material 37 h.
Total workload 104 h.

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0 - 5. Examination 70 %,written assignment 30 %.

**Course Materials:**

Crespo Márquez, A.: The Maintenance Management Framework: Models and Methods for Complex Systems Maintenance, Springer-Verlag, 2007.
Dhillon, B.S.: Engineering Maintenance: A ModernApproach, CRC Press, 2002.
Lecture notes.

**Places for exchange-students? (Yes, number/No):**

max 5

**Places for Open University Students?(Yes, number/No):**

max 5

**BH50A1500: Bioenergy Technology Solutions, 6 cr**

**Validity:** 01.08.2010 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Esa Vakkilainen

**Year:**

M.Sc. (Tech.) 2

**Period:**

2-3

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, D.Sc. (Tech.) Esa Vakkilainen

**Aims:**

Upon completion of the course the student will be able to 1. discuss the EU bioenergy policies including the effects of carbontrading, RES and energy efficiency, 2. understand the role and limitations of bioenergy use in Europe, 3. create a strategic vision for any country to usebioenergy, 4. understand different bioenergy generation technologies, and 5. list the biofuel production technologies, and 6. Independently follow discussions around future directions of Bioenergy technology. Independent creation of large report.

**Contents:**

Comparison of various bioenergy visions. Technological solutions and case studies from biomass supply and biofuelrefining, end-use technologies of biofuels in different sectors. Bioenergy challenges. Bioenergy politics.

**Teaching Methods:**

12 h of lectures. Group assignment. Written examination. Independent study approximately: Written assignment 48 h. Preparation for the examination 16 h + the examination 3 h. Studying given materials 77 h.
Total workload 156 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0 - 5. Examination 60 %, assignment 40 %.

**Course Materials:**

Lecture notes.

**Prerequisites:**

BH61A0600 Bioenergy.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

max 5

**BH61A0600: Bioenergy, 3 cr**

**Validity:** 01.08.2011 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Tapio Ranta

**Year:**

M.Sc. (Tech.) 1

**Period:**

1

**Teaching Language:**

English

**Teacher(s) in Charge:**

Tapio Ranta, D.Sc. (Tech.), Professor

**Aims:**

Upon completion of the course the student will be able to understand the meaning of bioenergy, alternative biomass resources,supply methods, refining and end-user applications; describe the quality properties of solid biofuels and how they are measured and evaluated by using standards; and explain the meaning of sustainability in bioenergy systems.

**Contents:**

The role of bioenergy in the EU energy policy,incentive programmes and future plans. Raw-material sources of bioenergy, potential resources and current use. Biomass supply systems and logistics. Refined biofuel commodities, biogas and liquid biofuels. Biomass international trade. Quality properties of solid biofuels, quality measurement and standards. Sustainable bioenergy.

**Teaching Methods:**

1st period: 12 h of lectures. Written examination 3 h. 63 h of self-study.
Total workload 78 h.

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0 - 5. Examination 100 %.

**Course Materials:**

Energy Visions 2050, VTT. 2009. Chapters 2, 4.4, 5.2- 5.4.
Additional material will be announced later during lectures.

**Places for exchange-students? (Yes, number/No):**

15–

**Places for Open University Students?(Yes, number/No):**

max 5

*List of selectable courses, choose enough courses to attain a min. of 23 ECTS. Either BH50A1200 or BH50A1400 must be included in this minor.*

**BH30A0701: Reliability Engineering, 4 cr**

**Validity:** 01.08.2014 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Juhani Hyvärinen, Elina Hujala

**Note:**

The course will be lectured every other year, next during the academic year 2018-2019.

**Lectured every other academic year (Yes, next realization year/Leave empty):**

Yes, 2018-2019.

**Year:**

M.Sc. (Tech.) 1-2.

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

D.Sc. (Tech.) Juhani Vihavainen, M.Sc. (Tech.), M.Sc. Elina Hujala.

**Aims:**

Upon completion of the course students will be able to calculate the reliability parameters for separate components and simple systems, formulate and solve fault and event trees for systems, and estimate the effect of human factors.

**Contents:**

Introduction to reliability engineering. Boolean algebra. The reliability parameters of components. The reliability engineering structure of systems, examples from different fields. Structural functions, reliability flow charts, fault trees, event trees, minimal cut sets. The reliability parameters of systems and their determination using different methods. Damage and effect analysis. The determination of parameters and trends from flaw observations. The improvement of the usage reliability of a system. Humans as a part of systems. Common mode failures and uncertainty analyses. The reliability of structures.

**Teaching Methods:**

Lectures 21 h, tutorials 14 h, 1st period. Lectures 21 h, tutorials 14 h, 2nd period. Preparation for the examination 31 h and written examination 3 h.
Total workload 104 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0 - 5. Examination 100 %. Possible to raise the grade by tutorials.

**Course Materials:**

Rausand M. & Hoyland A: System Reliability Theory, Models, Statisticals Methods and Applications.

**Prerequisites:**

Recommended BM20A1401 Tilastomatematiikka I or equivalent knowledge.

**Places for exchange-students? (Yes, number/No):**

max 10

**Places for Open University Students?(Yes, number/No):**

max 5

### BH40A1600: Turbomachinery in Renewable Energy, 5 cr

**Validity:** 01.08.2016 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Ahti Jaatinen-Värri, Jari Backman, Aki-Pekka Grönman, Antti Uusitalo

**Year:**

M.Sc. (Tech.) 2

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, D.Dc. (Tech.) Jari Backman, Associate professor, D.Sc. (Tech.) Aki Grönman, Associate professor, D.Sc. (Tech.) Ahti Jaatinen-Värri, Researcher, D.Sc. (Tech.) Antti Uusitalo

**Aims:**

Upon completion of the course the students are able to 1. To choose a right type of turbomachinery for each application 2. To design the main parameters of radial and axial flow turbines and radial compressors 3. To define the performance and efficiency of a turbomachine
4. To understand principles of flow theories behind design methodologies.

**Contents:**

Internal flows in turbomachinery, the design of an axial flow and radial flow turbines, the design of radial compressors, gas turbines, engine power plants, ORC-process and turbomachinery in it, operation of turbomachinery. The course is affiliated on the sustainability of energy systems and based on international scientific research.

**Teaching Methods:**

1st period, lectures + exercises 6 h, quizzes 4 h, case study 2 h, PBL tutorial 2 h, independent studies 26 h, 2nd period lectures + exercises 12 h, quizzes 6 h, case study 2 h, PBL tutorial 2 h, independent studies 68 h.
Total workload 130 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, PBL 40%, case 40% and quizzes 20%.

**Course Materials:**

Material Notebook, Moodle course material: summary, exercises, quizzes.

**Prerequisites:**

BH40A0801 Turbomachinery attended or ongoing.

**Places for exchange-students? (Yes, number/No):**

15-

**Places for Open University Students?(Yes, number/No):**

Max 5

### BL20A0401: Electricity Market, 5 cr

**Validity:** 01.08.2007 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Samuli Honkapuro

**Year:**

M.Sc. (Tech.) 1

**Period:**

1

**Teaching Language:**

English

**Teacher(s) in Charge:**

Associate Professor, D.Sc. (Tech.) Samuli Honkapuro

**Aims:**

Upon completion of the course the student will be able to: 1. describe the characteristics of the different business sectors in the Nordic electricity market, 2. explain electricity price formation, 3. explain the operation principle of the power exchange, 4. identify and describe
the products of the power exchange, 5. select the right risk management method for electricity trade, 6. describe the tasks of the different parties in an electric power system in maintaining technical and commercial power balance, including demand side management.

**Contents:**

The restructuring of the electricity markets, power exchange, electricity trade, balance management.

**Teaching Methods:**

28 h of lectures 10 h optional Moodle quizzes 1st period. 89 h independent studies. Written examination 3 h.
Total workload 130 h

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, examination 100%. Non-mandatory Moodle quizzes provide extra points to exam.

**Course Materials:**

Material distributed in Moodle.

**Places for exchange-students? (Yes, number/No):**

15–

**Places for Open University Students?(Yes, number/No):**

max 15

### BH50A1200: Energy Systems Engineering, 6 cr

**Validity:** 01.08.2007 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Esa Vakkilainen, Juha Kaikko

**Year:**

M.Sc. (Tech.) 1

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Docent, D.Sc. (Tech.) Juha Kaikko, D.Sc. (Tech.) Ekaterina Sermyagina

**Aims:**

Upon completion of thecourse the student will be able to 1. describe different types of energy production processes, 2. utilize thermodynamics and heat and mass balances inthe design of small scale energy systems, 3. use a “Systems Engineering” type approach to define the design values for energy production processes, 4. define small scale bioenergy production projects, 5. understand how plant requirements affect the planning and implementation phases of small energy systems, and 6. define economic constraints to small scale energy processes.

**Contents:**

History and fundamentals of thermodynamics and energy engineering. Modern problems of power plan tengineering. Combined heat and power production, especially from biomass. Fundamentals of steam

and gas turbines in energy production. Engineering design: heat and mass balances in the design of small scale energy systems. Systems engineering. Planning and implementation of energy systems. Economic optimization of energy system projects.

**Teaching Methods:**

1st period: 12 h of lectures and case exercises. 2nd period: 12 h of lectures and case exercises.Written assignment, written examination. Independent study approximately:Written assignment 80 h. Preparation for the examination 16 h and the examination3 h. Studying given material 33 h. Total workload 156 h.

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0 - 5. Examination 50 %,written assignment 50 %.

**Course Materials:**

Lecture notes.

**Prerequisites:**

Understanding of basic thermodynamics.

**Places for exchange-students? (Yes, number/No):**

max 5

**Places for Open University Students?(Yes, number/No):**

max 5

### BH50A1400: Steam Boilers, 6 cr

**Validity:** 01.08.2007 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Esa Vakkilainen

**Year:**

M.Sc. (Tech.) 2

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor D.Sc. (Tech.) Esa Vakkilainen

**Aims:**

Upon completion of the course the student will be able to 1. list typical biomass fuels and their properties, 2. understand the terminology used in maintenance management, 3. understand steam generation processes, especially from biomass, 4. describe the construction of steam boilers, 5. apply different types of steam boilers using different types of fuels, and 6. realize restrictions caused by corrosion, erosion and fouling.

**Contents:**

Characteristics of fuels, especially of biofuels. Combustion and gasification. Design of a steam boiler and its components. CCS. Energy balances. Solving steam boiler problems by mathematical modelling and algorithmization. Operation and maintenance of boilers: corrosion, fouling, emissions.

**Teaching Methods:**

1st period: 12 h of lectures and case exercises. 2nd period: 12 h of lectures and case exercises. Written assignment. Independent study approximately: Written assignment 48 h. Preparation for the examination 18 h and the examination 3 h. Studying given materials 63 h.
Total workload 156 h.

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5. Examination 70 %, written assignment 30 %.

**Course Materials:**

Lecture notes.
Teir, Sebastian: Steam Boiler Technology, 2nd ed. 2006.
Vakkilainen, Esa, Steam generation from Biomass, 2016.

**Prerequisites:**

Recommended: BH50A1200 Energy Systems Engineering.

**Places for exchange-students? (Yes, number/No):**

max 5

**Places for Open University Students?(Yes, number/No):**

max 5

## KeSoD400: Biobased Chemical Engineering, 20 - 30 cr

**Validity:** 01.08.2018 -

**Form of study:**

**Type:** Study module

**Unit:** LUT School of Engineering Science

**Grading:** Study modules 0-5,P/F

**Aims:**
After the completion of the minor in Biobased Chemical Engineering the student
• has knowledge of the modern bio-based industry, its processes and available raw materials
• has advanced knowledge of relevant unit processes used in bio-based industry
• has knowledge of sustainable solutions and technologies integrated to bio-refineries
• is able to seek out and understand scientific information to be applied in bio-based chemical engineering.

*Choose a min. of 20 ECTS. This minor is suitable for distance learning.*

### BJ02A1090: Environmental and Industrial Analytics, 5 cr

**Validity:** 01.01.2017 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Engineering Science

**Grading:** Study modules 0-5,P/F

**Teachers:** Satu-Pia Reinikainen, Eeva Jernström, Maaret Paakkunainen

**Note:**

The course is suitable for distance learning.

**Year:**

M.Sc. (Tech.) 1

**Period:**

4

**Teaching Language:**

English

**Teacher(s) in Charge:**

Satu-Pia Reinikainen, D.Sc. (Tech.), Professor
Maaret Paakkunainen, D.Sc. (Tech.)
Eeva Jernström, D.Sc. (Tech.)

**Aims:**

By the end of the course, the student is expected to be able to
- understand role and state-of-art of analytics in environmental and industrial contexts
- understand the effect of digitalization as the 4th industrial revolution
- be able to apply process management skills in implementation of project work.

**Contents:**

Main themes addressed are reliable sampling, traceability of measurements, modern instrumentation, data handling, process and environmental control/monitoring, and license to operate. Students will carry out a project work on one of these topics, report and present it as the visual synthesis. In addition a study visit aiming at
improved understanding of analytics will be carried out with a problem based learning procedure. Course contains tutorial lectures on the topics, hands on workshops on sampling, statistical process monitoring, and study visits.

**Teaching Methods:**

8 h of Tutorials, 2 h Study visit, 20 h Online workshops, 30 h Project work, 70 h Independent work. Total workload 130 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

Yes

**Examination in Exam (Yes/No):**

Yes

**Assessment:**

Numerical assessment (0-5); 40 % Electronic or Moodle Exam, 30 % Project Work, 30 % Other Homework.

**Course Materials:**

To be announced.

**Places for exchange-students? (Yes, number/No):**

max 15

**Places for Open University Students?(Yes, number/No):**

max 5

**BJ02A1100: Biorefineries, 5 cr**

**Validity:** 01.01.2018 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Engineering Science

**Grading:** Study modules 0-5,P/F

**Note:**

The course is suitable for distance learning.
This course is mainly directed to the students in the digital Master's Programme in Biorefineries.

**Year:**

M.Sc. (Tech.) 1

**Period:**

3

**Teaching Language:**

English

**Teacher(s) in Charge:**

Associate professor, D.Sc. (Tech.) Eeva Jernström

**Aims:**

By the end of the course, the student is expected to be able to
- Understand the basic concept of a biorefinery and the various alternative concepts
- Understand the main biorefining processes, e.g. kraft pulp process, production of biofuels, further processing of different bio-based raw materials.
- Have general knowledge of current biorefinery products, their applicability to different end-uses
- Apply management and cooperation skills in implementation of project work in combined virtual and f2f working environment.

**Contents:**

The course covers the most typical biorefining-processes currently in use as well as some selected future processes. Topics include raw materials for biorefineries, processes and process conditions, most common biorefinery products and their end-uses. The course includes Moodle assignments and project work. The project work will be carried out individually or in small groups that will define their own target, and working methodology. The course is suitable for distance learning.

**Teaching Methods:**

Tutorials and workshops 5 h, 2nd period. Project work 50 h. Self Study of predefined material 75 h. Total workload 130 h.
The course includes Moodle assignments and project work. The project work will be carried out individually or in small groups that will define their own target, and working methodology

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, Moodle assignments 60 %, Project work 40 %.

**Course Materials:**

Will be announced later.

**Limitation for students? (Yes, number, priorities/Leave empty):**

Yes, this course is mainly directed to the students in the digital Master's Programme in Biorefineries.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

max 5

**BJ02A1200: Bioeconomy, 5 cr**

**Validity:** 01.01.2018 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Engineering Science
**Grading:** Study modules 0-5,P/F

**Note:**

This course is suitable for distance learning.

**Year:**

M.Sc. (Tech.) 1

**Period:**

3-4

**Teaching Language:**

English

**Teacher(s) in Charge:**

Associate professor, D.Sc. (Tech.), Eeva Jernström
Professor, D.Sc. (Tech.) Mika Sillanpää

**Aims:**

By the end of the course, the student is expected to
- gain the basic understanding of various perspectives of bioeconomy
- gain updated knowledge of modern biorefineries and the basic prerequisites for operation and sustainable business.

**Contents:**

The study entities are: The multidimensional impact of bioeconomy on Europe, The implementation of bioeconomy, the sustainability – all three dimensions - aspects of bioeconomy. The course is carried as assignments based on selected topics from the book and additional material. Course is planned for distance learning.

**Teaching Methods:**

Individual studying and  assigments based on the book. Moodle is used as the learning platform.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, Moodle assigments 100 %.

**Course Materials:**

Book: A Sustainable Bioeconomy The green industrial revolution by Professors Mika Sillanpää and Chaker Ncibi.
Other related material announced later.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

max 5

### BJ02A1500: Current Issues in Enabling Technologies for Circular Economy, 5 cr

**Validity:** 01.01.2018 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Engineering Science
**Grading:** Study modules 0-5,P/F

**Note:**

The course is suitable for distance learning.

**Year:**

M.Sc. (Tech.) 1

**Period:**

4

**Teaching Language:**

English

**Teacher(s) in Charge:**

Jutta Nuortila-Jokinen, Docent, D.Sc., Associate professor

**Aims:**

The aim of this new course is to familiarise students widely into circular economy with the focus on the current and novel technologies that enable the transformation from linear to circular economy.

**Contents:**

The detailed content will be announced later. The course will be executed in co-operation with Oulu University.

**Teaching Methods:**

The course is 100 % digitalized.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

Yes

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5. Moodle exam and/or assignment. Details to be announced later.

**Course Materials:**

To be announced later.

**Places for exchange-students? (Yes, number/No):**

15–

**Places for Open University Students?(Yes, number/No):**

15–

### BJ02A1600: Biobased Materials and Advanced Organic Chemistry, 5 cr

**Validity:** 01.01.2018 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Engineering Science

**Grading:** Study modules 0-5,P/F

**Teachers:** Tiina Virtanen, Arto Pihlajamäki

**Year:**

M.Sc. (Tech.) 1

**Period:**

4

**Teaching Language:**

English

**Teacher(s) in Charge:**

Arto Pihlajamäki, D.Sc. (Tech.), Researcher/Teacher
Tiina Virtanen, M.Sc. (Tech.), Junior Researcher

**Aims:**

By the end of the course, a student is expected to:
- gain the basic chemical and technological understanding of the production of most important bioproducts from renewable resources
- be able to apply fundamental concepts of organic chemistry into application of biopolymers and their reactions.

**Contents:**

This course contains two modules. Biobased Materials module will introduce novel biomaterials and focus on properties of biobased polymers, their processing, reactions and applications. Advanced Organic Chemistry module gives extended knowledge in the structure and reactivity of organic biomolecules. There are lists of literature recommended for each module. Students will work in small groups on selected topics.

**Teaching Methods:**

Moodle lessons: Module 1 60 h, Module 2 60 h, 4th period. Quizzes and activities in Moodle 10 h. Total workload 130 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

Yes

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, Moodle exam, assignments and fulfilled activities in Moodle, project work reports in Modules 1 and 2.

**Course Materials:**

To be announced.

**Prerequisites:**

BJ01A1040 Orgaanisen kemian perusteet (Basic Organic Chemistry) or equivalent knowledge.

**Limitation for students? (Yes, number, priorities/Leave empty):**

Yes, 50, Students in Chemical Engineering M.Sc. programme.

**Places for exchange-students? (Yes, number/No):**

max 5

**Places for Open University Students?(Yes, number/No):**

max 5

### BJ02A4070: Principles of Thermal Gas-Liquid Processes, 5 cr

**Validity:** 01.01.2018 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Engineering Science

**Grading:** Study modules 0-5,P/F

**Year:**

M.Sc. (Tech.) 1

**Period:**

2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, D.Sc. (Tech.) Tuomas Koiranen

**Aims:**

Student understands distillation, evaporation and gas scrubbing technologies, including equipment structures and sizing principles. Student can design gas-liquid contactors by hand, is able to form mathematical calculation models, and can apply equations for computer simulation.

**Contents:**

Gas-liquid contactor theory, sizing principles and equations, calculation examples, computer exercises. Distillation, evaporation, gas scrubbing.

**Teaching Methods:**

Combined lectures and exercises 10 h, homeworks 72 h, self learning 48 h.
Total workload 130 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

Yes

**Examination in Exam (Yes/No):**

No

**Assessment:**

Examination grading scale 0-5. minimum 75 % of homeworks correct, returning to moodle.

**Course Materials:**

Course books:
Niket S. Kaisare, Computational Techniques for Process Simulation and Analysis Using MATLAB®, Taylor&Francis, 2017

Hussein K. Abdel-Aal, Chemical Engineering Primer with Computer Applications, Taylor&Francis, 2016
Felder, R.M., Elementary Principles of Chemical Processes, Wiley, 2004

**Prerequisites:**

BM20A1501 Numerical Methods or equivalent, BM20A4301 Introduction to Technical Computation or equivalent

**Places for exchange-students? (Yes, number/No):**

max 10

**Places for Open University Students?(Yes, number/No):**

max 5

## MaDSaCompu: Computer Vision and Pattern Recognition, 20 - 30 cr

**Validity:** 01.08.2018 -

**Form of study:**

**Type:** Study module

**Unit:** LUT School of Engineering Science

**Grading:** Study modules 0-5,P/F

**Aims:**
Learning Outcomes:
By the end of minor, the student:
- has knowledge in pattern recognition and in methods for intelligent computing
- is able to formulate and select approaches for problems in imaging
- is able to computationally solve problems and evaluate the solutions in data analysis
- understands the limitations in modelling and the computational challenges for applications in the analysis of real data
- is able to find innovative ways to solve practical problems
- is able to work with incomplete data, model innovative solutions and search for novel options
- understands the applicable area of the methods in intelligent computing
- is able to work in a team in various roles
- is able to communicate the methods, problems, applications, and solutions in various forums both orally and in written form
- is able to perform clustering, classification using neural networks with complex data
- is able to use modern computational technologies in data analysis

*Obligatory Studies 12 ECTS cr*

### BM40A0701: Pattern Recognition, 6 cr

**Validity:** 01.01.2016 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Engineering Science

**Grading:** Study modules 0-5,P/F

**Teachers:** Lasse Lensu

**Year:**

M.Sc. (Tech.) 1

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, D.Sc. (Tech.) Lasse Lensu

**Aims:**

After passing the course, students understand pattern recognition problems and know the common approaches including machine learning methods to solve them. The students are able to select an appropriate pattern recognition method and implement a working solution for a specific problem. The students can analyse the performance and quality of a pattern recognition system.

**Contents:**

Introduction to pattern recognition, supervised and unsupervised machine learning. Feature processing, selection and system evaluation. Statistical pattern recognition and Bayesian inference. Linear and non-linear classifiers such as the perceptron, artificial neural networks and support vector machines. Context-dependent and reinforcement learning. Unsupervised pattern recognition and method-independent learning.

**Teaching Methods:**

Lectures 14 h, lecture preparation 7 h, exercises 14 h, exercise preparation 21 h, 1st period.
Lectures 14 h, lecture preparation 7 h, exercises 14 h, exercise preparation 21 h, practical assignment 40 h, 2nd period. Self-study 4 h. Total amount 156 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

Yes

**Assessment:**

0 - 5. Homework and exercises 30%, exercise quizzes (or exam) 40%, practical assignment 30%.

**Course Materials:**

Duda, R.O., Hart, P.E., Stork, D.G.: Pattern Classification, Wiley, 2001. Theodoridis, S., Koutroumbas, K.: Pattern Recognition, Academic Press, 2003.

**Prerequisites:**

Recommended BM20A4301 Johdatus tekniseen laskentaan, BM20A5001 Principles of Technical Computing, BM20A5800 Funktiot, lineaarialgebra ja vektorit, BM20A5810 Differentiaalilaskenta ja sovellukset, BM20A5820 Integraalilaskenta ja sovellukset, BM20A5840 Usean muuttujan funktiot ja sarjat, CT60A0210 Käytännön ohjelmointi, BM20A1401 Tilastomatematiikka I, BM20A1501 Numeeriset menetelmät I, BM20A1601 Matriisilaskenta, BM40A0501 Johdatus laskennalliseen älykkyyteen, or equivalent knowledge.

**Places for exchange-students? (Yes, number/No):**

max 5

**Places for Open University Students?(Yes, number/No):**

max 5

### BM40A1201: Digital Imaging and Image Preprocessing, 6 cr

**Validity:** 01.01.2016 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Engineering Science

**Grading:** Study modules 0-5,P/F

**Teachers:** Tuure Tuuva, Lasse Lensu, Erik Vartiainen

**Year:**

M.Sc. (Tech.) 1

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Associate Professor, D.Sc. (Tech.) Arto Kaarna, Professor, Ph.D. Tuure Tuuva, Associate Professor, Ph.D. Erik Vartiainen.

**Aims:**

A student knows how radiation interacts with matter, how images can be captured and the image formation modelled, and how preprocessed images can be used for measurement purposes. The student is able to characterise imaging and the factors affecting it, and affect image quality in practice.

**Contents:**

Electromagnetic radiation and light interaction with matter, sources of radiation and illumination techniques, imaging sensors and manufacturing technologies, spectroscopy, imaging optics, sensor and image acquisition modelling and characterisation, digital image encoding and characteristics, image preprocessing techniques, and image-based measurement.

**Teaching Methods:**

Lectures 14 h, lecture preparation 7 h, exercises 14 h, exercise preparation 14 h, 1. period.
Lectures 14 h, lecture preparation 7 h, exercises 14 h, exercise preparation 14 h, practical assignment 40 h, 2. period.
Self-study 18 h. Total amount 156 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

Yes

**Assessment:**

0 - 5. Homework and exercises 25 %, exercise quizzes (or exam) 50 %, practical assignment 25 %.

**Course Materials:**

Kasap, S.O.: Optoelectronics and Photonics, Prentice-Hall, 2000. Gonzales, R.C., Woods, R.E.: Digital image processing, Prentice-Hall, 2002. Jain, A.K.: Fundamentals of digital image processing, Prentice-Hall, 1989.

**Prerequisites:**

Recommended BM20A4301 Johdatus tekniseen laskentaan, BM20A5001 Principles of Technical Computing, BM40A0502 Johdatus laskennalliseen älykkyyteen ja koneoppimiseen, or equivalent knowledge.

**Places for exchange-students? (Yes, number/No):**

max 5

**Places for Open University Students?(Yes, number/No):**

max 5

*Choose enough courses to attain at least 20 ECTS cr together with obligatory courses*

**BM10A1100: Advanced Methods in Mathematics, Computing and Physics, 3 - 6 cr**

**Validity:** 01.08.2016 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Engineering Science

**Grading:** Study modules 0-5,P/F

**Teachers:** Erkki Lähderanta, Arto Kaarna, Jouni Sampo

**Year:**

M.Sc. (Tech.) 2

**Period:**

1-4

**Teaching Language:**

English

**Teacher(s) in Charge:**

Associate Professor, D.Sc. (Tech.) Arto Kaarna, Professor, Ph.D. Erkki Lähderanta, University Lecturer, D. Sc. (Tech.) Jouni Sampo.

**Aims:**

The student is able to employ theoretical and operational skills in some specific area of applied mathematics, computing, and technical physics. The student is able to select, apply, and analyze methods to modeling problems in mathematics, science and engineering. Entrepreneurial learning methods are applied.

**Contents:**

The course consists of literature review, working on exercises and completing practical projects. Materials will be chosen and agreed individually according to the focus of the study module, students' interests, and research in the laboratories. The course with the same title can be included in the study programme twice when two distinct areas are covered.

**Teaching Methods:**

Self-study of learning materials, exercises, project assignment and reporting, seminar presentation, total 80-160 h, 1st-4th period.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

Pass/Fail, report and seminar presentation 100 %.

**Course Materials:**

Learning materials will be agreed with each student separately depending on the task(s).

**Prerequisites:**

Recommended: BSc. in Computational Engineering and Technical Physics, first year studies in the specialization of the M.Sc. studies.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

No

**BM20A3001: Statistical Analysis in Modelling, 5 cr**

**Validity:** 01.08.2008 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Engineering Science
**Grading:** Study modules 0-5,P/F
**Teachers:** Heikki Haario

**Note:**

Suitable also for doctoral studies

**Year:**

M.Sc. (Tech.) 1

**Period:**

3

**Teaching Language:**

English

**Teacher(s) in Charge:**

Post-Doctoral Researcher, D.Sc. (Tech.) Virpi Junttila

**Aims:**

Introduction to modern computational methods of estimating reliability of modeling and simulation results. After the course, the student is able to estimate parameters of nonlinear models by measured data and to create posterior distributions for parameters and model predictions by MCMC (Markov chain Monte Carlo) methods.

**Contents:**

Introduction to the methods of estimating reliability of modelling. Errors and uncertainty in experimental data. Uncertainty in model parameters and prediction results. Bayesian approach for parameter estimation and inverse problems, various Monte Carlo (MCMC) methods for nonlinear models.

**Teaching Methods:**

Lectures 21 h, exercises 14 h, homework 35 h, practical assignment 38 h, preparation for examination and the examination 22 h, 2nd period. Total 130 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, examination 100 %.

**Course Materials:**

To be given at the lectures.

**Prerequisites:**

First year university calculus, BM20A1401 Tilastomatematiikka I. Recommended BM20A6500 Simulation and System Dynamics.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

max 15

### BM20A3401: Design of Experiments, 4 cr

**Validity:** 01.08.2008 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Engineering Science

**Grading:** Study modules 0-5,P/F

**Teachers:** Heikki Haario, Marko Laine, Satu-Pia Reinikainen, Maaret Paakkunainen

**Note:**

Suitable also for doctoral studies.

**Year:**

M.Sc. (Tech.) 1-2

**Period:**

4

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, Ph.D. Heikki Haario

**Aims:**

After the course, the student is expected to master the basic skills for effective experimentation, together with regression analysis of data:
- understanding of the importance of designed experiments
- ability to apply the basic experimental plans, and regression techniques to analyse the results
- skills to optimize an engineering process using design of experiments and data analysis.

**Contents:**

Importance of experimental design, minimization of prediction uncertainty of regression models. Basic factorial designs: 2N, Central Composite designs for regression analysis. The Taguchi principles. Experimental optimisation of engineering processes.

**Teaching Methods:**

Lectures 21 h, exercises 14 h, homework 21 h, experimental work in laboratory 26 h, preparation for examination and the examination 22 h, 4th period. Total 104 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, examination 70 %, project work 30 %.

**Course Materials:**

Box, G., Hunter, S., Hunter, W. G.: Statistics for Experimenters, Wiley 2005, 2nd Edition.

**Prerequisites:**

First year university calculus, BM20A1401 Tilastomatematiikka I/basic statistics. Basic (Matlab) skills for technical computing with PC.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

max 15

### BM20A5001: Principles of Technical Computing, 4 cr

**Validity:** 01.08.2014 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Engineering Science

**Grading:** Study modules 0-5,P/F

**Teachers:** Matylda Jablonska-Sabuka

**Year:**

B.Sc. (Tech.) 2., M.Sc. (Tech.) 1

**Period:**

1

**Teaching Language:**

English

**Teacher(s) in Charge:**

D.Sc. (Tech.) Matylda Jablonska-Sabuka

**Aims:**

Students get a good understanding of Matlab syntax and programming, gain fluency in principles of technical computing and are able to apply the skills to basic mathematical and engineering problems (the skills are applicable in big part to Octave and R programming, too).

**Contents:**

Working with various data structures (multidimensional arrays, cell arrays, etc.) and variable types (numeric, logical, textual, etc.), Matlab symbolic functionality, conditional statements (if-else, switch-case), loops (for and while), using built-in functions, handling external data, 2-D and 3-D plotting, writing user-defined functions, optimization of code speed, style and efficiency.

**Teaching Methods:**

Lectures 12 h, computer class exercises 24 h, independent study 30 h, preparation for exam 34 h, 1st period. Total 100 h. EXAM-tentti.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

Yes

**Assessment:**

0-5, examination 100 %.

**Course Materials:**

Lecture material available in Moodle, based partly on textbook: Gilat, A.: An Introduction to Matlab with Applications.

**Prerequisites:**

Basic university calculus required. Recommended first year university calculus necessarily including matrix calculus.

**Places for exchange-students? (Yes, number/No):**

max 10

**Places for Open University Students?(Yes, number/No):**

max 5

### BM20A6200: Inverse Problems and Normed Spaces, 6 cr

**Validity:** 01.08.2016 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Engineering Science

**Grading:** Study modules 0-5,P/F

**Teachers:** Jouni Sampo

**Year:**

M.Sc. (Tech.) 1

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

University lecturer, D.Sc. (Tech.) Jouni Sampo

**Aims:**

The student knows the concepts of function spaces and related basic terminology of functional analysis. Student understand and is able to use classical methods for solving linear inverse problems like of estimation of signal from incomplete or corrupted measurements.

**Contents:**

Vector spaces, bases and linear operators. Linear subspaces and projections. Norms, metric and convergence. Various function spaces, Banach spaces, Lp-spaces, Hilbert spaces. Formulation of inverse problems with additive noise. Ill-posedness and inverse crimes. Truncated singular value decomposition for inverse problems, Tikhonov and total variation regularization.

**Teaching Methods:**

Lectures 21 h, exercises 14 h, independent study and homework 40 h, 1st period. Lectures 21 h, exercises 14 h, independent study and homework 43 h, 2nd period. Exam 3h. Total 156 h.

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, exam 100 %

**Course Materials:**

Study material will be informed/distributed through the Moodle portal.

**Prerequisites:**

Basic Matlab skills are required (in 2nd period). BM20A1601 Matrix calculus is recommended.

**Places for exchange-students? (Yes, number/No):**

max 5

**Places for Open University Students?(Yes, number/No):**

max 15

### BM40A0801: Machine Vision and Digital Image Analysis, 6 cr

**Validity:** 01.08.2016 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Engineering Science
**Grading:** Study modules 0-5,P/F
**Teachers:** Heikki Kälviäinen

**Note:**

The course will be lectured every other year, next during the academic year 2019-2020.

**Lectured every other academic year (Yes, next realization year/Leave empty):**

Yes, next realization year 2019-2020

**Year:**

M.Sc. (Tech.) 1-2

**Period:**

3-4

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, D.Sc. (Tech.) Heikki Kälviäinen

**Aims:**

After the course a student is expected to be able to explain the fundamental steps of image processing and analysis, to introduce and compare machine vision applications, to plan a solution to a given object recognition problem, and to implement practical solutions for machine vision problems using Matlab or other suitable programming language.

**Contents:**

Digital image processing: digital image, image transforms, image enhancement, image compression. Image analysis: segmentation, representation and description, recognition and interpretation. Hardware, software and applications.

**Teaching Methods:**

Lectures and seminars 21 h, exercises 14 h, 3rd period. Lectures and seminars 21 h, exercises 14 h, 4th period. Preparation for the seminar presentations and acting as an opponent, homework, and practical assignment 47 h, self-studying of taught matters and relevant literature and preparation for the exam 36 h, 3rd and 4th period. Exam 3 h. Total amount 156 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Doctoral School course where enrollment is in WebOodi (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, exam 50 %, exercises 50 %. Seminar presentation. Acting as an opponent. Practical assignment.

**Course Materials:**

References and material published on the course web page.

**Prerequisites:**

Recommended BM40A0701 Pattern Recognition, BM40A0901 Computer Vision, BM40A1201 Digital Imaging and Image Preprocessing,BM40A0502 Johdatus laskennalliseen älykkyyteen ja koneoppimiseen

**Places for exchange-students? (Yes, number/No):**

max 5

**Places for Open University Students?(Yes, number/No):**

No

## BM40A0901: Computer Vision, 6 cr

**Validity:** 01.08.2016 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Engineering Science
**Grading:** Study modules 0-5,P/F
**Teachers:** Arto Kaarna

**Note:**

The course will be lectured every other year, next during the academic year 2018-2019.

**Lectured every other academic year (Yes, next realization year/Leave empty):**

Yes, 2018-2019.

**Year:**

M.Sc. (Tech.) 1-2

**Period:**

3-4

**Teaching Language:**

English

**Teacher(s) in Charge:**

Associate Professor, D.Sc. (Tech.) Arto Kaarna

**Aims:**

A student knows the theoretical basis of geometric and dynamic computer vision, and is able to apply the knowledge to solve practical problems in computer vision. A student is able to explain basic approaches and applications for image processing and feature extraction for single images and video sequences. Student is able to implement simple application in computer vision.

**Contents:**

Computer vision for 3D scenes. Imaging and camera calibration. Image preprocessing. Coordinate frames and geometrical primitives. Single and multi-view geometry. Pose estimation. Dynamic vision and tracking. Structure from motion. Computer vision for robotics.

**Teaching Methods:**

Lectures 14 h, exercises 12 h, exercise preparation 12 h, 3rd period.
Lectures 14 h, exercises 14 h, exercise preparation 14 h, seminar 3h, practical assignment and seminar preparation 42h, 4th period.
Independent study 28h, exam 3 h. Total 156 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5:
0-2, exam, exercises, practical assignment if the grade from the exam is 0, 1 or 2.
3-5, exam (60 %), exercises (40 %), practical assignment if the grade from the exam is 3, 4, or 5.

**Course Materials:**

Emanuele Trucco, Alessandro Verri: Introductory Techniques for 3-D Computer Vision. Prentice Hall, 1998. E. R. Davies: Computer and Machine Vision, Fourth Edition: Theory, Algorithms, Practicalities, 4th Edition. Elsevier, 2012. Richard Hartley, Andrew Zisserman: Multiple View Geometry in Computer Vision, 2nd Edition. Cambridge University Press, 2004. David A. Forsyth, Jean Ponce: Computer Vision: A Modern Approach, 2nd Edition. Prentice Hall, 2011.

**Prerequisites:**

BM20A6700 Matematiikka I
BM20A6800 Matematiikka II
BM20A6800 Matematiikka II
CT60A0200 Ohjelmoinnin perusteet.
Recommended
BM20A1401 Tilastomatematiikka I,
BM20A1501 Numeeriset menetelmät I,
BM20A1601 Matriisilaskenta,
BM20A5500 Differentiaaliyhtälöt ja dynaamiset systeemit
BM40A0501 Johdatus laskennalliseen älykkyyteen or equivalent knowledge.

**Places for exchange-students? (Yes, number/No):**

max 5

**Places for Open University Students?(Yes, number/No):**

max 5

### BM40A1400: GPGPU Computing, 6 cr

**Validity:** 01.08.2016 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Engineering Science
**Grading:** Study modules 0-5,P/F
**Teachers:** Arto Kaarna, Aleksandr Bibov

**Year:**

M.Sc. (Tech.) 1-2

**Period:**

Intensive week 43, periods 2 and 3.

**Teaching Language:**

English

**Teacher(s) in Charge:**

Associate Professor, D.Sc. (Tech.) Arto Kaarna, D.Sc. (Tech.) Alexander Bibov.

**Aims:**

The student is able to reorganize computational tasks in order to best fit a given GPU architecture. The student is able to implement inter-operability between a GPU-boosted code and MATLAB/Python environment.

**Contents:**

GPGPU (General Purpose Graphics Processing Unit) programming architecture, solving problems using GPGPU. CUDA-implementations and interface to GPGPU hardware. Parallel algorithms, hybrid application design for CPU/GPGPU. Introduction to visualization of computed data. Practical implementations for artificial toy-cases and real engineering applications.

**Teaching Methods:**

Lectures 20 h, exercises 15 h, pre-assignment 24 h, intensive week 43. Seminar 4 h, post-assignment and seminar preparation, 93 h, periods 2 and 3. Totally 156 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, report and seminar presentation on the assignment.

**Course Materials:**

Popular GPU-accelerated Applications, http://www.nvidia.com/docs/IO/123576/nv-applications-catalog-lowres.pdf. Other materials will be announced at lectures.

**Places for exchange-students? (Yes, number/No):**

max 5

**Places for Open University Students?(Yes, number/No):**

max 5

**CS38A0060: Fuzzy sets and fuzzy logic, 6 cr**

**Validity:** 01.01.2018 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Business and Management

**Grading:** Study modules 0-5,P/F

**Teachers:** Pasi Luukka

**Year:**

M.Sc. (Tech) 2.

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Pasi Luukka, D.Sc. (Tech.), Professor

**Aims:**

By the end of the course student will be able to

- understand basic mathematical concepts related to fuzzy set theory and fuzzy logic
- model uncertain concepts using fuzzy set theory
- construct fuzzy models
- deduce meaningful information from fuzzy models

**Contents:**

The course consists of basics of fuzzy set theory, some algebras of fuzzy sets, fuzzy quantities, logical aspects of fuzzy sets, operations of fuzzy sets, fuzzy relations, fuzzy compositional calculus, aggregation operators, possibility theory, fuzzy inference systems.

**Teaching Methods:**

Lectures 14 h, tutorials 7 h, exercises 14 h, 1st period. Lectures 14 h, tutorials 7 h, exercises 14 h, 2nd period. Independent study 90 h. Written examination. Total workload 160 h.

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, examination 100 %.

**Course Materials:**

Klir, G., Yuan, B.: Fuzzy Sets and Fuzzy Logic. Theory and Applications, Prentice Hall, 1995.
Fullér, R.: Introduction to Neuro-Fuzzy Systems, Physica-Verlag, 2000.

**Prerequisites:**

Bachelor level mathematics courses:
BM20A6700 Matematiikka I, osa A , BM20A6800 Matematiikka II, osa A, BM20A6900 Matematiikka III
Experience in programming or using mathematical software required:
BM20A4301 Johdatus tekniseen laskentaan or BM20A5001 Principles of Technical Computing

**Number of exercise groups where enrollment is in WebOodi (Number/Leave empty):**

1

**Places for exchange-students? (Yes, number/No):**

max 10

**Places for Open University Students?(Yes, number/No):**

max 10

### CS38A0070: Fuzzy data analysis, 6 cr

**Validity:** 01.01.2018 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Business and Management

**Grading:** Study modules 0-5,P/F

**Teachers:** Pasi Luukka

**Year:**

M.Sc. (Tech.) 2

**Period:**

3

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, D.Sc. (Tech.) Pasi Luukka

**Aims:**

In the end of the course the student is expected to be able to

- understand theoretical aspects of data analysis
- understand basic mathematics from fuzzy set theory related to data analysis
- apply fuzzy set theory based models in data analysis
- analyze and interpret results from the models
- apply fuzzy principal component analysis, fuzzy clustering and classification methods to data analysis problems

**Contents:**

Fuzzy sets and relations. Uncertainty measures. Qualitative and quantitative analysis of fuzzy data. Principles of individual multi-person, multi-criteria decision making, feature selection, fuzzy principal component analysis, fuzzy clustering and classification, fuzzy regression analysis.

**Teaching Methods:**

Lectures 28 h, exercises 28 h. Practical assignment. Independent study 100 h. Total work load 156 h.

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Number of mid-term examinations:**

No

**Assessment:**

0-5, examination 100 %. Practical assignment.

**Course Materials:**

Bandemer, H., Näther, W.: Fuzzy Data Analysis, Kluwer Academic Publ., 1992.

**Prerequisites:**

CS38A0060 Fuzzy sets and fuzzy logic

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

Yes, max 10

## SaDsähk: Electrical Engineering, 20 cr

**Validity:** 01.08.2015 -

**Form of study:**

**Type:** Study module

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Aims:**

Sähkötekniikan sivuopinnot (SaDsähk) on tarkoitettu sähkötekniikan DI-opiskelijoille.

**Sähköverkot**

Opiskelija osaa suunnitella sähkönjakeluverkkoja ja johtaa sähköverkkoliiketoiminnan kehittämistä, sisältäen sähköteknisen suunnittelun, suojauksen suunnittelun, verkkojen teknis-taloudellisen mitoituksen sekä sähköverkkoliiketoiminnan strategisen suunnittelun ottaen huomioon sähköverkkoihin liittyvän regulaation rajoitteet ja mahdollisuudet. Lisäksi opiskelija osaa hyödyntää alan tuoreinta tutkimustietoa ja tunnistaa keskeiset teknisen ja sähkömarkkinakehityksen vaikutukset sähköenergiajärjestelmässä.

**Electricity Market**

Opiskelija osaa selittää sähkö- ja päästöoikeusmarkkinoiden toiminnan pääpiirteet ja pystyy soveltamaan näitä tietoja ja taitoja sähkömarkkinoiden operatiivisessa toiminnassa. Lisäksi opiskelija osaa hyödyntää alan tuoreinta tutkimustietoa ja tunnistaa keskeiset teknisen ja sähkömarkkinakehityksen vaikutukset sähköenergiajärjestelmässä. Sähkömarkkinoiden opintojen rinnalle sopivat esim. sähköverkkojen ja uusiutuvan energian ja energiatehokkuuden opinnot sekä kauppatieteen ja/tai tuotantotalouden kurssit ja sivuainepaketit.

**Electrical Drives**

Opiskelija hallitsee sähkökäyttöjen järjestelmäkokonaisuuksia (sis. mm. taajuudenmuuttaja, sähkömoottori tai -generaattori ja mekaaninen kuorma). Opiskelija ymmärtää pyörivien sähkökoneiden vektorisäätömenetelmiä ja osaa suunnitella taajuudenmuuttajan ohjaus- ja säätöalgoritmeja sekä sovellustason ohjelmia. Opiskelija osaa mallintaa eri sähkökoneiden toimintaa sekä käyttää sähkömekaanisten järjestelmien ja sen osien simulointityökaluja. Lisäksi opiskelija osaa mitoittaa ja valita sovelluskohteeseen sopivat sähkökäytön komponentit.

**Power Electronics**

Opiskelija osaa kuvata keskeisimpien tasa- ja vaihtosuuntaajien sekä hakkuriteholähteiden toiminta- ja ohjausperiaatteet. Opiskelija osaa myös suunnitella tehoelektroniikan päävirtapiiriratkaisuja eri sovelluskohteisiin ja mitoittaa laitteiden jäähdytyksen. Lisäksi opiskelija osaa suunnitella sähkömagneettisia komponentteja sekä tunnistaa keskeiset häviömekanismit ja häiriölähteet.

**Design of Electrical Machines**

Opiskelija osaa suunnitella ja käyttää sähkökoneita sekä kehittää sähkökäyttöjen järjestelmäkokonaisuuksia (sis. mm. taajuudenmuuttaja, sähkömoottori tai -generaattori ja mekaaninen kuorma). Opiskelija osaa mallintaa ja simuloida sähkömoottorikäyttöjä sekä soveltaa numeerisen kenttäratkaisun työkaluja. Opiskelija osaa suunnitella taajuudenmuuttajan sovellustason ohjelmia. Lisäksi opiskelija osaa perusteet taajuusmuuttajien ohjaus- ja säätöalgoritmien kehittämiseksi.

**Electric Conversion Systems**

Opiskelija tuntee erilaisten tehoelektroniikkapohjaisten sähköenergianmuuntojärjestelmien keskeisimmät toimintaperiaatteet, komponenttiteknologian ja säätöperiaatteet. Opiskelija osaa suunnitella perustopologian sekä valita ja mitoittaa komponentit erilaisiin sähköenergian muuntosovelluksiin. Opinnoissa perehdytään erityisesti teollisuuskäyttöihin, laivasähköjärjestelmiin, sähköisten kulkuneuvojen tehojärjestelmiin sekä smart-grid ja tuuli- ja aurinkovoimalateknologiaan.

**Solar Economy**
Opiskelija osaa kuvata uusiutuvan energiantuotannon laitetekniikkaa sekä tunnistaa uusiutuvan energiantuotannon projekteihin ja talouteen liittyviä kysymyksiä. Tämän lisäksi opiskelija osaa kuvata ja selittää uusiutuvan energian muuntoprosesseja sekä kykenee luotettavaan investointi- ja systeemisuunnitteluun.
**Control and Automation**
Opiskelija osaa laatia säätösovelluksille vaatimusmäärittelyt sekä suunnitella, toteuttaa ja testata vaatimukset täyttävän säätöjärjestelmän myös osana laajempaa tuotekehitysprojektia. Opiskelija osaa muodostaa järjestelmälle ja sen komponenteille dynaamisen mallin ja simuloida sitä. Opiskelija osaa suunnitella digitaalisia säätöalgoritmeja ja mittaussignaalin digitaalisen suodatuksen. Opiskelija on perehtynyt automaation laite- ja järjestelmätekniikkaan ja osaa valita säätöjärjestelmään soveltuvat järjestelmäkomponentit ja tiedonsiirtoratkaisut. Opiskelija osaa toteuttaa säätöjärjestelmän ohjelmallisesti automaatiolaitteessa tai sulautetussa ohjauselektroniikassa. Sovellustarkasteluissa painotetaan erityisesti sähkökäyttöihin ja tehoelektroniikkaan liittyviä suunnittelutehtäviä.
**Embedded Systems**
Opiskelija osaa suunnitella ja toteuttaa sulautettuja järjestelmiä hyödyntäen yleisimpiä ohjelmointi- ja kuvauskieliä. Lisäksi opiskelijalla on valmiudet työskennellä osana tuotekehitysprojektia, jossa laitteiston tai palvelun toteutus perustuu sulautetun järjestelmän, eli esimerkiksi mikrokontrollerin, ohjausalgoritmeihin. Opintojen pääpaino on sulautettujen järjestelmien ohjelmoinnissa sekä digitaalisten suodattimien suunnittelussa.
**Elektroniikan komponentit**
Opiskelija osaa hyödyntää keskeisimpiä elektroniikkasuunnittelun työkaluja ja käyttää elektroniikan perusmittalaitteita tuotekehitys- ja tutkimustyössä. Opiskelija osaa soveltaa elektroniikan komponentteja elektronisen laitteen suunnittelussa ja hyödyntää alan uusinta tutkimustietoa.
**Elektroniikan tuotesuunnittelu**
Opiskelijalla on keskeiset tiedot ja taidot elektroniikkasuunnitteluprojektin läpiviemiseksi. Hän osaa hyödyntää keskeisimpiä elektroniikkasuunnittelun työkaluja ja käyttää elektroniikan perusmittalaitteita tuotekehitys- ja tutkimusprojekteissa. Opinnot suoritetaan pääasiassa projektimuotoisesti.
**Microelectronics**
Opiskelija osaa kuvata puolijohdekomponenttien rakennetta, toimintaa ja fysiikkaa. Lisäksi opiskelija osaa mallintaa integroitujen piirien komponenttien toimintaa simulointiohjelmistolla. Opiskelija osaa myös kuvata mikroelektroniikan valmistuksen vaiheet ja menetelmät sekä hyödyntää alan uusinta tutkimustietoa.

*Valitse sivuopintokokonaisuuteen yksi moduuli ja täydennä sitä tarvittaessa 20 op laajuuteen muiden moduulien opintojaksoilla. Choose one of the elective specialisation modules. If the size of the elective module is less than 20 cr., the remaining credits are selected from the other modules.*

**SaDsä: Sähköverkot, 23 - 28 cr**

**Validity:** 01.08.2014 -
**Form of study:** Major studies
**Type:** Study module
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F

No course descriptions.

*Valinnainen moduuli 23 op*

**BL20A1600: Smart Grids, 5 cr**

**Validity:** 01.08.2016 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Jarmo Partanen, Jukka Lassila, Samuli Honkapuro, Tero Kaipia

**Note:**

The course is suitable for distance learning.

**Year:**

M.Sc. (Tech.) 1-2

**Period:**

3-4

**Teaching Language:**

English

**Teacher(s) in Charge:**

Associate Professor, D.Sc. Samuli Honkapuro

**Aims:**

Upon completion of the course the student will be able to 1. Label the key elements and functionalities of the smart grid system 2. Analyze the impacts of the smart grid elements on electricity distribution system and electricity markets 3. Document and present orally the results of the seminar work 4. Provide both written and oral peer review.

**Contents:**

Smart grid concept, demand side management, energy storages, distributed generation, microgrids, communications in smart grids. In addition, annually changing topical subjects.

**Teaching Methods:**

Lectures 14 h, Moodle quizzes 7 h in 3rd period. Independent seminar work 100 h. Presentation of the seminar work 2 h,
peer review of a written seminar work 5 h and working as an opponent in seminar 2 h in 4th period. Course is suitable for distance learning.
Total workload 130 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5. The course is evaluated based on seminar work (written and oral presentation), Moodle quizzes, and student’s work as a reviewer and an opponent.

**Course Materials:**

Study materials handed out in Moodle.

**Prerequisites:**

Attending the course BL20A0500 Sähkönjakelutekniikka (Electricity distribution) OR BL20A0401 Electricity Market OR BL20A0400 Sähkömarkkinat (Electricity Market)

**Places for exchange-students? (Yes, number/No):**

max 10

**Places for Open University Students?(Yes, number/No):**

max 5

**BL20A0500: Electricity Distribution Technology, 8 cr**

**Validity:** 01.08.2007 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Jukka Lassila, Jarmo Partanen

**Note:**

The course is suitable for distance learning.

**Year:**

M.Sc. (Tech.) 1

**Period:**

2-3

**Teaching Language:**

Finnish

**Teacher(s) in Charge:**

Professor, D.Sc. (Tech.) Jarmo Partanen

**Aims:**

Upon completion of the course the student will be able to: 1. perform technical and financial calculations related to electricity distribution networks: voltages, currents, losses, fault currents, reliability, investment, outage and maintenance costs, 2. compile long-term strategic development plans related to electricity distribution networks, 3. carry out techno-economic dimensioning of an electricity distribution network, 4. explain the targets and principles of the use of electricity distribution networks, 5. use the distribution automation applications in the operation of a distribution network and design short circuit and earth fault protection in electricity distribution networks. 6. Have understanding of Smart Concept and it’s impact on electricity distribution business.

**Contents:**

Network technology and planning, operation of distribution system, protection and automation of distribution networks, information systems of distribution companies, Smart Grids, industrial networks.

**Teaching Methods:**

Personal interview. 42 h of lectures, 28 h of tutorials, 2nd and 3rd period. Assignment 60 h. Written examination 3 h. Independent working 75 h.  The lectures focus on the core learning objectives in the topic. Successful completion of the course requires student’s active independent work. The course is suitable for distance learning.
Total workload 208 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, examination 100 %. Satisfactorily completed assignment required giving some extra points to exam evaluation.

**Course Materials:**

Lakervi, E. & Partanen, J.: Sähkönjakelutekniikka (Otatieto, moniste 609).
Lecture materials + videos in Moodle.

**Prerequisites:**

BL20A0700 Introduction to Electrical Power Systems, BL20A0600 Electrical Power Transmission and BL20A0400 Electricity Market attended.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

max 5

## BL20A0600: Electrical Power Transmission, 5 cr

**Validity:** 01.08.2007 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Jarmo Partanen, Jouni Haapaniemi

**Note:**

The course is suitable for distance learning.

**Year:**

M.Sc. (Tech.) 1

**Period:**

2

**Teaching Language:**

Finnish

**Teacher(s) in Charge:**

Professor, D.Sc. (Tech.) Jarmo Partanen

**Aims:**

Upon completion of the course the student will be able to: 1. describe the operation principle of an electric power system, 2. explain and determine the principles of frequency and voltage control in an electric power system, including the special features of the Nordel system, 3. calculate the power flow and fault currents in meshed power transmission systems, 4. calculate the static and transient stability of a single generator, 5. describe the basic techniques and application targets of DC transmission, 6. explain the implementation principles of fault protection in a meshed power transmission network.

**Contents:**

The description of the electricity transmission system. Frequency and voltage control. Calculation of load flow, fault currents and stability in a meshed network. DC power transfer. Relay protection.

**Teaching Methods:**

24 h of lectures, 28 h of tutorials, homework 2nd period. Written examination 3h. Independent working 71 h. The lectures focus on the core learning objectives in the topic. Successful completion of the course requires student’s active independent work. The course is suitable for distance learning.
Total workload 130 h.

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, examination 100%.

**Course Materials:**

Mörsky: Voimalaitosten yhteiskäytön tekniikka (Otatieto Moniste 549).
Mörsky: Relesuojaustekniikka. (Otatieto, moniste 540).
Elovaara, Haarla: Sähköverkot I ja II. (Otatieto, 2011, ISBN 978-951-672-360-3)
Kothari, Nagrath: Modern Power System Analysis. (Tata McGaw-Hill, 2003, ISBN 0-07-049489-4).
Lecture notes and video in Moodle.

**Prerequisites:**

Students are required to have completed BL30A0000 Electric Circuits and BL20A0700 Introduction to Electrical Power Systems.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

max 5

### BL20A1001: Protection of Electricity Networks, 5 cr

**Validity:** 01.08.2013 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Janne Karppanen, Jukka Lassila, Tero Kaipia

**Note:**

Luennoidaan joka toinen vuosi, seuraavan kerran lukuvuonna 2019-20.

**Lectured every other academic year (Yes, next realization year/Leave empty):**

Yes, 2020 spring

**Year:**

M.Sc. 1-2

**Period:**

4

**Teaching Language:**

Finnish

**Teacher(s) in Charge:**

D.Sc. (Tech.) Jukka Lassila

**Aims:**

Upon completion of the course the student will be able to: 1. explain the properties of the protection relays and the general criteria for the design of the relay protection of the electricity network, 2. design the relay protection schemes for the short circuit and earth fault protection of the electricity distribution network and for the distance relay protection of the electricity transmission network, 3. recognise the impacts of the distributed generation to the relay

protection of the electricity distribution network, and to consider these impacts in the planning of the protection schemes, 4. name the most common differences in the principles of the relay protection of different types of electricity networks, 5. recognise the most important properties of current and voltage transformers and circuit breakers from the relay protection perspective, and perform basic dimensioning of these components.

**Contents:**

Basic principles of the fault protection of electric power networks. Different protection relays, overcurrent relays, distance relays, differential relays, arc protection, over voltage protection. Insulation co-ordination. Protection of network lines, cables and transformers. Planning of the relay protection.

**Teaching Methods:**

Lectures 21 h, calculation exercises 14 h, 3rd period. Examination. The lectures focus on the core learning objectives in the topic. Successful completion of the course requires student's active independent work.
Total workload 130 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, exam 100 %.

**Course Materials:**

Elovaara, Haarla: Sähköverkot II (Otatieto),
Mörsky: Relesuojaustekniikka (Otatieto, moniste 540) material handed out in class.
Aro, Martti et al.: Suurjännitetekniikka. Otatieto Oy, 2003.

**Prerequisites:**

Students are recommended to have completed BL20A0700 Sähköverkkotekniikan peruskurssi, and participation in courses BL20A0500 Sähkönjakelutekniikka and BL20A0600 Sähkönsiirtotekniikka.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

max 15

## SaDEK: Elektroniikan komponentit, 21 - 24 cr

**Validity:** 01.08.2014 -
**Form of study:** Major studies
**Type:** Study module
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F

No course descriptions.

*Obligatory*

**BL50A1300: Advanced Course in Electronics, 6 cr**

**Validity:** 01.08.2008 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Pertti Silventoinen, Jero Ahola

**Year:**

M.Sc. (Tech.) 1

**Period:**

3-4

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, D.Sc. (Tech.) Pertti Silventoinen

**Aims:**

The student prepares a seminar presentation on a new topic in electronics. Upon completion of the course the student will be able to demonstrate in-depth knowledge of a new topic in electronics.

**Contents:**

The course contents are subject related and will be specified during the introductory lectures.

**Teaching Methods:**

2 h of introductory lectures, 12 h of seminar presentations, 3rd period. 12 h of seminar presentations, 4th period. No written examination. Independent work 130 h.
Total workload 156 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Doctoral School course where enrollment is in WebOodi (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, seminar presentation. Peer review. 100 %.

**Course Materials:**

The material will be specified in the introductory lecture.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

max 5

**BL50A1400: Analog Electronics, 6 cr**

**Validity:** 01.08.2008 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Heikki Järvisalo, Pertti Silventoinen

**Year:**

M.Sc. (Tech.) 1

**Period:**

1-2

**Teaching Language:**

Finnish

**Teacher(s) in Charge:**

Professor, D.Sc. (Tech.) Pertti Silventoinen
Junior researcher, M.Sc. (Tech.) Heikki Järvisalo

**Aims:**

Upon completion of the course the student will be able to: 1. name the most significant components in analog electronics and describe the basic operating principles of the components 2. dimension the biasing circuit of a transistor amplifier 3. analyse the transistor amplifiers using small signal models, 4. recognise and describe the properties of practical operational amplifiers and their effects on amplifier design.

**Contents:**

Basic components in analog electronics, diodes, transistors, integrated circuits. Differential and operational amplifiers, multistage amplifiers, power amplifiers, oscillators. Analog special components.

**Teaching Methods:**

12 h of lectures, 12 h of tutorials, 1st period. 12 h of tutorials, 8 h of laboratory work, 12 h of assignment writing, 2nd period. Assignment 1st-2nd period. Independent study 97 h. Written examination 3h.
Total workload 156 h.

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, written examination (50 %), tutorials (25 %) and assignment (25 %).

**Course Materials:**

Lecture slides
Electronic Devices, Thomas L. Floyd
Microelectronics, Jacob Millman
Microelectronic circuits, Sedra & Smith

**Prerequisites:**

BL50A0100 Basic Analog Electronics recommended.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

max 5

### BL50A1600: Electronics, Laboratory Course 2, 3 - 6 cr

**Validity:** 01.08.2013 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Tommi Kärkkäinen

**Year:**

M.Sc. (Tech.) 1-2

**Period:**

1-4

**Teaching Language:**

Finnish

**Teacher(s) in Charge:**

Post-doctoral researcher, D.Sc. (Tech) Tommi Kärkkäinen

**Aims:**

Upon completion of the course the student will be able to: 1. apply theoretical studies of other courses to practical electronics design, problem solving and prototype construction, 2. use multimeters, oscilloscopes, signal generators, power supplies and other measuring instruments, 3. analyse the operation of circuits based on measurements, 4. produce a scientific, technical report, 5. act as a team member in an electronics project and bear their responsibility of the success of the project.

**Contents:**

Electronics laboratory work and prototype testing, the use of measuring instruments. Electronics design, testing, troubleshooting, hand soldering, electronics circuit simulation, project work and project management.

**Teaching Methods:**

Defining, implementing and documenting an electronics project. Electronics design, laboratory work and reporting, 1st-4th period. Personal assignments 16 h, project work 62-138 h.
Total workload 78-156 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

1-5. Assessment based on the produced documentation and the success of the project 80 %, and personal tasks 20 %.

**Course Materials:**

Moodle material, material announced in class.

**Prerequisites:**

BL50A0502 Electronics, Laboratory Course 1.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

max 5

**Description and DL of the company assignment:**

Small and simple electronics design projects are carried out on the course. The students write a specification document for the device to be constructed, build a prototype and test and document the outcome of the project.
Deadline for the assignments is 31.8. Contact: Tommi Kärkkäinen, tommi.karkkainen@lut.fi, +358 40 148 8341

## BM30A0601: Optoelectronics, 6 cr

**Validity:** 01.08.2009 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Engineering Science

**Grading:** Study modules 0-5,P/F

**Teachers:** Ekaterina Soboleva, Erkki Lähderanta, Bernardo Barbiellini

**Year:**

M.Sc. (Tech.) 1

**Period:**

1

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, Ph.D. Bernardo Barbiellini
Junior Researcher, M.Sc.(Tech.) Ekaterina Soboleva

**Aims:**

Students get a good understanding of the basics of optoelectronics and photonics and are able to deal with the following topics: optical data communication, construction of wave guides using total internal reflection and working principles of light emitting diodes and photodetectors.

**Contents:**

Wave nature of light, dielectric waveguides and optical fibers, working principals of light emitting diodes, LASERs and photovoltaic devices. Computation tasks to consolidate knowledge.

**Teaching Methods:**

Lectures 28 h, exercises 14 h, preparation for exam 114 h, 1st period. Examination.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, examination 100 %.

**Course Materials:**

Kasap, S. O.: Optoelectronics and Photonics P. Silfsten & E. Vartiainen: Optoelektroniikka,

**Prerequisites:**

Basic knowledge about optics.

**Places for exchange-students? (Yes, number/No):**

max 5

**Places for Open University Students?(Yes, number/No):**

max 5

**SaDET: Elektroniikan tuotesuunnittelu, 17 - 24 cr**

**Validity:** 01.08.2014 -
**Form of study:** Major studies
**Type:** Study module
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F

No course descriptions.

*Obligatory*

**BL20A0100: Thermal Design of an Electric Device, 3 cr**

**Validity:** 01.08.2007 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Janne Nerg

**Note:**

The course is suitable for distance learning.

**Year:**

M.Sc. (Tech.) 1

**Period:**

3

**Teaching Language:**

Finnish

**Teacher(s) in Charge:**

Associate professor, D.Sc. (Tech.) Janne Nerg

**Aims:**

Upon completion of the course the student will be able to 1. perform thermal design of a simple electronic device, 2. describe the heat transfer mechanisms and 3. analytically calculate temperature distribution of an electronic device.

**Contents:**

Heat transfer mechanisms, cooling methods of electronic devices, the effect of the operation temperature on the performance of an electronic device, thermal resistance networks, numerical calculation methods in thermal engineering.

**Teaching Methods:**

Lectures 14 h, exercises 14 h, home assignments, 3rd period. Examination or continuous assesment. Course is suitable for distance learning. Total workload 78 h.

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0–5, examination or continuous assesment 100 %.

**Course Materials:**

Course material is found from Moodle.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

max 5

### BL50A0802: Electronic Equipment and Systems Design, 7 cr

**Validity:** 01.08.2015 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Pertti Silventoinen, Mikko Kuisma, Tommi Kärkkäinen

**Year:**

M.Sc. (Tech.) 1

**Period:**

1-3

**Teaching Language:**

Finnish

**Teacher(s) in Charge:**

Professor, D.Sc. (Tech.) Pertti Silventoinen

**Aims:**

Upon completion of the course the student will be able to: 1. write functional and other requirements for an electronic device, 2. apply the knowledge from previous courses to electronics prototype and larger system design, 3. recognise the key differences between prototype design and industrial production design and take these differences into account in equipment design, 4. apply the acquired design skills from circuit level to complete devices and systems. 5.analyse technical conceptions and manufacturability of an electrical device 6. document and present the projects.

**Contents:**

Prototype design, designing electronics for mass production, specifying large electronic systems. Test planning. Seminar presentations held by students on topics varying from year to year.

**Teaching Methods:**

7 h of lectures, 1st period. Team meetings 12 h, 2-3rd period. Design project work in teams. Independent study 163h.
Total workload 182 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5. Completing the project work. Students role in the teamwork, self and peer review.

**Course Materials:**

Materials given in steering meetings and in the lectures

**Prerequisites:**

Basics of analog and digital electronics. Motivation to design and build electronics. Ability to work in teams.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

max 5

**Description and DL of the company assignment:**

The course is based on the design projects form companies. The projects typically include electronics design, simulation, prototyping and embedded programming. The project ideas from the companies should be received by the end of August.

### BL50A0900: Analog Signal Processing, 6 cr

**Validity:** 01.08.2007 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Mikko Kuisma

**Year:**

M.Sc. (Tech.) 1

**Period:**

1-3

**Teaching Language:**

Finnish

**Teacher(s) in Charge:**

Associate professor, D.Sc. (Tech.) Mikko Kuisma

**Aims:**

Upon completion of the course the student will be able to: 1. carry out a small electronics design and testing project 2. design an analog circuitry, such as a modulator and a filter 3. design and match a line driver for a cable (< 1 GHz), 4. work as a part of an electronics design team in a project.

**Contents:**

Signal analysis of analog and analog/digital systems. Transmission line theory in practical cabling the use of line driver and termination in applications below 1GHz. Signal integrity. Prototype design and debugging. The course focuses on a customer-oriented design and practical implementation of an electronic system (“Mobile speaker” - portable audio player). During the project work we also train and learn group dynamics and project management.

**Teaching Methods:**

Lectures and coaching 14 h 1st period. Project work - Independent study 142 h.
Total workload 156 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5. Project and documentation, participation in the project, peer and self assessment.

**Course Materials:**

To be announced in class.

**Prerequisites:**

BL50A1400 Analog electronics recommended.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

max 5

### BL50A1700: Electronics project, 2 - 8 cr

**Validity:** 01.08.2014 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Mikko Kuisma, Pertti Silventoinen

**Note:**

Mainly independent team project for persons who already have experience on completing project.

**Year:**

M.Sc. (Tech.) 2

**Period:**

1-4

**Teaching Language:**

Finnish

**Teacher(s) in Charge:**

D.Sc. (Tech.) Mikko Kuisma

**Aims:**

Upon completion of the course the student will be able to: 1. apply the knowledge obtained from electronics courses to practice, 2. design an electronics device or a specified part of an electronics device that meets the given requirements, 3. work in an electronics R&D team, 4. place his/her work into the context of an R&D project, 5. communicate issues related to the project with other project team members.

**Contents:**

Depends on the yearly project, typically: properties of electronics components, design and thermal design of electronics, measurements and signal processing, embedded system design, implementation, and programming, EMC, applications of power electronics, protection in an electronic device.

**Teaching Methods:**

Implementation of an electronics device in a project group. Independent study 52-208 h.
Total workload 52-208 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, project work, peer assessment and reporting 100 %.

**Prerequisites:**

Previous experience on project work, either work experience or project courses e.g. Project work, Analog signal processing, Electronic Equipment and Systems Design

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

No

**SaDMI: Microelectronics, 20 cr**

**Validity:** 01.08.2014 -
**Form of study:** Major studies
**Type:** Study module
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F

No course descriptions.

*Elective module 20 ECTS cr.*

**BL50A1300: Advanced Course in Electronics, 6 cr**

**Validity:** 01.08.2008 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Pertti Silventoinen, Jero Ahola

**Year:**

M.Sc. (Tech.) 1

**Period:**

3-4

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, D.Sc. (Tech.) Pertti Silventoinen

**Aims:**

The student prepares a seminar presentation on a new topic in electronics. Upon completion of the course the student will be able to demonstrate in-depth knowledge of a new topic in electronics.

**Contents:**

The course contents are subject related and will be specified during the introductory lectures.

**Teaching Methods:**

2 h of introductory lectures, 12 h of seminar presentations, 3rd period. 12 h of seminar presentations, 4th period. No written examination. Independent work 130 h.
Total workload 156 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Doctoral School course where enrollment is in WebOodi (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, seminar presentation. Peer review. 100 %.

**Course Materials:**

The material will be specified in the introductory lecture.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

max 5

**BM30A1600: Microelectronics, 6 cr**

**Validity:** 01.08.2008 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Engineering Science

**Grading:** Study modules 0-5,P/F

**Teachers:** Erkki Lähderanta, Ekaterina Soboleva, Bernardo Barbiellini

**Year:**

M.Sc. (Tech.) 1

**Period:**

1

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, Ph.D. Bernardo Barbiellini
Junior Researcher, M.Sc.(Tech.) Ekaterina Soboleva

**Aims:**

Studentsget a good understanding of microelectronics basics and main integrated circuit(IC) components, students gain fluency to the most important variables and functions relatedto the IC components, and are able to apply their skills to analog IC design.

**Contents:**

Considering the basic components (PN junctions, metal-oxide-semiconductor, bipolar junction transistors, MOSFET, diodes, and amplifiers) of integrated circuit and their operation principles. Computation tasks and simulation to facilitate understanding.

**Teaching Methods:**

Lectures 28 h, exercises and tutorials 28 h, assignment 40 h, preparation for exam 60 h. Assignment and its presentation. Written examination.

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, examination 100 %. Satisfactorily completed assignment required.

**Course Materials:**

Roger T. Howe, Charles G. Sodini: Microelectronics An Integrated Approach.

**Prerequisites:**

Recommended BL40A1711 Johdanto digitaalielektroniikkaan and BL50A1400 Analogiaelektroniikka.

**Places for exchange-students? (Yes, number/No):**

max 5

**Places for Open University Students?(Yes, number/No):**

max 5

**BM30A1701: Physics of Semiconductor Devices, 6 cr**

**Validity:** 01.08.2013 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Engineering Science
**Grading:** Study modules 0-5,P/F
**Teachers:** Tuure Tuuva

**Year:**
M.Sc. (Tech.) 2
**Period:**
1-2
**Teaching Language:**
English
**Teacher(s) in Charge:**
Professor, Ph.D. Tuure Tuuva
**Aims:**
Student will acquire an in-depth knowledge of semiconductor diode, CCD, MOSFET, LED and photodiode and their operation.
**Contents:**
Structure, operation and physics of semiconductor devices.
**Teaching Methods:**
Special assignment 102 h, seminars 28 h, 1st-2nd period. Total workload 130 h.
**Suitability for doctoral studies (Yes/Leave empty):**
Yes
**Examination in Examination schedule (Yes/No):**
No
**Examination in Moodle (Yes/No):**
No
**Examination in Exam (Yes/No):**
No
**Assessment:**
Pass/fail, seminar presentation 100 %.
**Course Materials:**
Sze, Physics of Semiconductor Devices.
**Places for exchange-students? (Yes, number/No):**
No
**Places for Open University Students?(Yes, number/No):**
max 5

**BM30A2100: Microelectronics Processing Technology, 2 cr**

**Validity:** 01.08.2009 -
**Form of study:** Basic studies
**Type:** Course

**Unit:** LUT School of Engineering Science

**Grading:** Study modules 0-5,P/F

**Teachers:** Tuure Tuuva

**Year:**

M.Sc. (Tech.) 1

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, Ph.D. Tuure Tuuva

**Aims:**

To provide the student with a basic knowledge of microelectronics processing technology and components. Oxidation, diffusion and metallization.

**Contents:**

Purification of semiconductor materials. Growth of semiconductor crystals and wafer preparation. Epitaxial layers, diffusion, ion implantation, oxidation, etching and photolithography. Semiconductor manufacturing and development.

**Teaching Methods:**

Special assignment 52 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, seminar and/or written assignment 100 %.

**Course Materials:**

Plummer, J. D., Deal, M. D., Griffin, P. B., Silicon VLSI Technology: Fundamentals, Practice and Modeling.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

max 5

**SaDEIMa: Electricity Market, 22 - 23 cr**

**Validity:** 01.08.2017 -

**Form of study:**

**Type:** Study module

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

No course descriptions.

*Elective module 22-23 ECTS cr.*

**BL20A0201: Power Exchange Game for Electricity Markets, 3 cr**

**Validity:** 01.08.2007 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Nadezhda Belonogova, Samuli Honkapuro

**Year:**

M.Sc. (Tech.) 1

**Period:**

2-3

**Teaching Language:**

English

**Teacher(s) in Charge:**

M.Sc. (Tech.) Nadezda Belonogova

**Aims:**

Upon completion of the course the student will be able to: Plan electricity purchase and sale in an economically viable way, recognize the most common risk management instruments and basic mechanisms of demand response in electricity markets, and exploit financial products of the power exchange in risk management and trade electricity in day ahead and intraday markets. These skills will be practised in a power exchange game, after which the student will be able to analyse and interpret the game results.

**Contents:**

Electricity purchase/sale, OTC markets, physical products on the power exchange (Elspot and Elbas), financial products on the power exchange (DS Futures and Futures), risk management.

**Teaching Methods:**

Lectures 8 h, weekly game situation practice 40 h, 2nd and 3rd period. Written homework 4h, intermediate report 4h and final report 10h. Independent work 12h. The lectures focus on the key learning objectives in the topic. Successful completion of the course requires student's active independent work.
Total workload 78 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, written report 100 %.

**Course Materials:**

Course material in Moodle.

**Prerequisites:**

BL20A0401 Electricity Market.

**Places for exchange-students? (Yes, number/No):**

max 5

**Places for Open University Students?(Yes, number/No):**

max 5

### BL20A1600: Smart Grids, 5 cr

**Validity:** 01.08.2016 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Jarmo Partanen, Jukka Lassila, Samuli Honkapuro, Tero Kaipia

**Note:**

The course is suitable for distance learning.

**Year:**

M.Sc. (Tech.) 1-2

**Period:**

3-4

**Teaching Language:**

English

**Teacher(s) in Charge:**

Associate Professor, D.Sc. Samuli Honkapuro

**Aims:**

Upon completion of the course the student will be able to 1. Label the key elements and functionalities of the smart grid system 2. Analyze the impacts of the smart grid elements on electricity distribution system and electricity markets 3. Document and present orally the results of the seminar work 4. Provide both written and oral peer review.

**Contents:**

Smart grid concept, demand side management, energy storages, distributed generation, microgrids, communications in smart grids. In addition, annually changing topical subjects.

**Teaching Methods:**

Lectures 14 h, Moodle quizzes 7 h in 3rd period. Independent seminar work 100 h. Presentation of the seminar work 2 h,
peer review of a written seminar work 5 h and working as an opponent in seminar 2 h in 4th period. Course is suitable for distance learning.
Total workload 130 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5. The course is evaluated based on seminar work (written and oral presentation), Moodle quizzes, and student's work as a reviewer and an opponent.

**Course Materials:**

Study materials handed out in Moodle.

**Prerequisites:**

Attending the course BL20A0500 Sähkönjakelutekniikka (Electricity distribution) OR BL20A0401 Electricity Market OR BL20A0400 Sähkömarkkinat (Electricity Market)

**Places for exchange-students? (Yes, number/No):**

max 10

**Places for Open University Students?(Yes, number/No):**

max 5

### BH60A4400: Introduction to Sustainability, 3 cr

**Validity:** 01.08.2013 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Mirja Mikkilä, Virgilio Panapanaan, Risto Soukka

**Year:**

M.Sc. (Tech.) 1

**Period:**

1

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, D.Sc. (Tech.) Risto Soukka

**Aims:**

Upon completion of the course the students are expected to be able to:
1) explain the interaction between the environment, society and business and understand the relationships of various actors in these fields and their impacts on the society and the environment,
2) understand the core idea and thinking behind sustainability and its importance in order to limit or decelerate environmental damages and improve our quality of life while pursuing a more sustainable lifestyle and business within the planetary boundaries,
3) understand and apply practically the learned principles and concepts of sustainability in relation to current production and consumption habits,
4) know and be guided about the different value-adding activities and tools that promote sustainability

**Contents:**

The idea is to learn and understand sustainability challenges and their interconnectedness, and find out how we could move or transit towards a more sustainable world.

**Teaching Methods:**

1st period: 14 h of lectures. Independent study (approx. 64 h): assignment (group work) and seminar (approx. 26 h). Preparation for the examination and the exam (approx. 38 h). Total workload 78 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

Yes

**Examination in Exam (Yes/No):**

No

**Assessment:**

0 - 5. Examination 60 %, assignment 40 %.

**Course Materials:**

Will be announced during lectures. Moodle.

**Places for exchange-students? (Yes, number/No):**

max 5

**Places for Open University Students?(Yes, number/No):**

max 5

### BH60A5700: Business and Sustainability, 6 cr

**Validity:** 01.01.2018 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F

**Note:**

Replaces the course BH60A3001 Corporate Responsibility and Management 2.

**Year:**

M.Sc. (Tech.) 1

**Period:**

3-4

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, D.Sc. (Econ. & Bus. Adm.), M.Sc. (Tech.) Lassi Linnanen
Associate Professor, D.Sc. (Agr. & For.) Mirja Mikkilä

**Aims:**

Upon the completion of the course the student is expected to be able to:
1. analyze decision making situations related to sustainable business,
2. propose solutions to challenging business situation within sustainable business,
3. understand various sustainable business and enterprise models,
4. evaluate critically responsible corporate communication,
5. discuss and argument on various perspectives of sustainable business based on the learned issues and on-going societal debate.
6. carry out self- and peer evaluations

**Contents:**

Familiarization with the sustainable business models and the strategic responsibility framework of a firm. Reorganization of dimensions of responsible business. Deepening the application skills of mechanisms and tools of sustainable management. Analysisof business and financial

consequences of responsibility governance. Familiarization of basics of business ethics. Communication and reporting ofgoals and implementation of corporate responsibility to stakeholders. Learning of corporate responsibility reporting guidelines.

**Teaching Methods:**

Lectures 6 h, 3 period. Written report on Corporate Responsibility communication and preparation of seminar presentation, groupwork approximately 30 h, written report 3 period.
Seminar presentation 4. period. Case-assignments, group work, approximately 120 h, 3-4 period. The student mustparticipate in the case-assignments.
Total workload 156 h, of which independent work approximately 118 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Doctoral School course where enrollment is in WebOodi (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

Evaluation 0 - 5. Written report 30 %, case-assignments 70 %.

**Course Materials:**

Caset: Hamschmidt, Jost (toim.): Case studies in sustainability management and strategy: the Oikos collection, 2007,
Pirson, Michael (toim.): Case studies in social entrepreneurship: the Oikos collection, 2015,
GRI yhteiskuntavastuun raportointiohjeisto, versiot 3.1 ja 4. Further course material will beannounced during the lectures,
Course material in Moodle

**Prerequisites:**

Sustainability transition and sustainable business (Kestävyysmuutos ja johtaminen) or Introduction to Sustainable Business
passed or equivalent knowledge studied earlier.

**Places for exchange-students? (Yes, number/No):**

Max 5

**Places for Open University Students?(Yes, number/No):**

Max 5

*Choose Electricity Market, if you have not studied it earlier. Otherwise, choose Investointihankkeiden elinkaarilaskelmat (taught in Finnish only).*

**BL20A0401: Electricity Market, 5 cr**

**Validity:** 01.08.2007 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Samuli Honkapuro

**Year:**

M.Sc. (Tech.) 1

**Period:**

1

**Teaching Language:**

English

**Teacher(s) in Charge:**

Associate Professor, D.Sc. (Tech.) Samuli Honkapuro

**Aims:**

Upon completion of the course the student will be able to: 1. describe the characteristics of the different business sectors in the Nordic electricity market, 2. explain electricity price formation, 3. explain the operation principle of the power exchange, 4. identify and describe
the products of the power exchange, 5. select the right risk management method for electricity trade, 6. describe the tasks of the different parties in an electric power system in maintaining technical and commercial power balance, including demand side management.

**Contents:**

The restructuring of the electricity markets, power exchange, electricity trade, balance management.

**Teaching Methods:**

28 h of lectures 10 h optional Moodle quizzes 1st period. 89 h independent studies. Written examination 3 h.
Total workload 130 h

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, examination 100%. Non-mandatory Moodle quizzes provide extra points to exam.

**Course Materials:**

Material distributed in Moodle.

**Places for exchange-students? (Yes, number/No):**

15–

**Places for Open University Students?(Yes, number/No):**

max 15

### CS31A0610: Life-Cycle Costing of Investment Projects, 6 cr

**Validity:** 01.08.2016 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Business and Management

**Grading:** Study modules 0-5,P/F

**Teachers:** Timo Kärri, Sini-Kaisu Kinnunen

**Note:**

Can't be included into a same degree as CS31A0603 Life-Cycle Costing of Investment Projects.

**Year:**

M.Sc. 1-2

**Period:**

1

**Teaching Language:**

Finnish

**Teacher(s) in Charge:**

Professor, D.Sc. (Tech.) Timo Kärri
M.Sc. (Tech.) Sini-Kaisu Kinnunen

**Aims:**

After completing the course students will be able to:
- prepare and evaluate investment proposals
- analyze requirements of sustainability during the life-cycle of projects.

**Contents:**

Investment proposal. Life-cycle of investment project, life-cycle costs and profits, capital costs, initial investment and working capital, classification and selection of projects, uncertainty and risks. Evaluation methods introduced: net present value, internal rate of return, return on investment, payback period, benefit-cost ratio and profitability index. Investment process, timing and financing of projects, public-private partnership, life-cycle models of machine replacements, concept of real option, evaluation of projects from the perspective of sustainability.

**Teaching Methods:**

Lectures 26 h, exercises 10 h, micro-execises 9 h, homeworks 12 h, individual tasks 64 h, preparation for exam and exam 36 h, 1. period. Total 157 h.

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0 - 5. Exam, extra points from assignments.

**Course Materials:**

Lecture notes (2 copies). Mott, Graham: Investment appraisal. Pitman Publishing, 1997, (196 p.). Götze U. et al: Investment appraisal - Methods and models. Springer. 2008, (341 p.)

**Prerequisites:**

CS31A0102 Kustannusjohtamisen peruskurssi

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

max 5

**SaDEIDri: Electrical Drives, 25 cr**

**Validity:** 01.08.2017 -

**Form of study:**

**Type:** Study module

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

No course descriptions.

*Elective module 25 ECTS cr.*

**BL30A0600: Power Electronics, 6 cr**

**Validity:** 01.08.2007 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Lasse Laurila

**Note:**

The course is suitable for distance learning.
Course has examination in Examination schedule, but it is not traditional paper exam. The exam will be done with computer.

**Year:**

M.Sc. (Tech.) 1

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Associate professor, D.Sc. (Tech.) Lasse Laurila

**Aims:**

Upon completion of the course the student will be able to: 1. demonstrate good general knowledge of the different basic main circuits in modern power electronics, 2. describe the features and functions of different rectifiers, switch-mode converters and inverters, 3. calculate and simulate typical design tasks of the aforementioned circuits, 4. describe the joint operation of static converters and loads as well as the network interferences caused by converters and alternatives to reduce these interferences.

**Contents:**

Operation of the main circuits of different power converters: rectifiers (single and three-phase), DC-DC switch mode converters and power supplies (buck, boost, buck-boost, flyback, forward), inverters (single and three-phase), resonance converters (ZVS, ZCS). Characteristics and operation. Pulse width modulation (PWM). Harmonic components. Simulation of power electronic circuits (simulation tools used: PSpice and Matlab/Simulink, calculations on Mathcad, Excel). Possible extra assignments to gather extra points to the exam.

**Teaching Methods:**

Combined lectures and tutorials, 28 h, 1st period. Combined lectures and tutorials, 28 h, 2nd period. Moodle-examination, 3 h. Independent study 97 h. The course is suitable for distance learning.
Total workload 156 h.

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

Yes

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, examination 100 %. 75 % of tutorial tasks passed or 75 % active presence in tutorials. Possible extra assignments to gather extra points to the exam.

**Course Materials:**

Mohan, Undeland, Robbins: Power Electronics, converters, applications, and design. Chapters 1 to 18.
Course material in Moodle.

**Prerequisites:**

Recommended: BL30A0000 Electric Circuits. Integration and derivation (esp. sine and cosine functions).
FFT. Laplace transforms. Basic software skills with Excel, Word.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

max 5

### BL30A0901: Power Electronic Components, 5 cr

**Validity:** 01.08.2016 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Lasse Laurila

**Note:**

The course is suitable for distance learning.
Course has examination in Examination schedule, but it is not traditional paper exam. The exam will be done with computer.

**Year:**

M.Sc. (Tech.) 1

**Period:**

3-4

**Teaching Language:**

English

**Teacher(s) in Charge:**

Lasse Laurila, D.Sc. (Tech.), Associate professor

**Aims:**

After the course the student can: 1. describe the properties, operation and suitable applications of different power electronic devices, passive components and electrical energy storages. 2. calculate the losses of the device and design suitable cooling and protection. 3. Simulate and analyse switching phenomena of power electronic components.

**Contents:**

Basic semiconductor physics, pn-junction, power semiconductor devices, passive components, mobile power electronics, electrical energy storages (batteries, supercapacitors). Operation principles of power electronic switches, switching phenomena, losses, applications. Manufacturing

methods, gate and base drive circuits, cooling methods, protection methods. Simulation of power electronic components. Possible extra assignments to gather extra points to the exam.

**Teaching Methods:**

Combined lectures and tutorials, 28 h, 3. period. Combined lectures and tutorials, 28 h, 4th period. Moodle examination 3 h. Independent study 71 h. The course is suitable for distance learning. Total workload 130 h.

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

Yes

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, examination 100 %. 75 % of tutorial tasks passed or 75 % active presence in tutorials. Possible extra assignments to gather extra points to the exam.

**Course Materials:**

Mohan, Undeland, Robbins: Power Electronics, converters, applications, and design. Chapters 19-29.
Course material in Moodle.
Recommended to follow also additional material listed in Moodle and lecture materials.

**Prerequisites:**

BL30A0000 Electric Circuits. Integration and derivation.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

max 5

### BL30A1001: Electrical Drives, 8 cr

**Validity:** 01.08.2010 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Juha Pyrhönen

**Note:**

The first part (2nd period) will be studied in collaboration with BL30A1020 Electrical Drives, Compact. Common lectures, exercises and homework. The student may participate either in “Electrical Drives, Compact” or “Electrical Drives”, not in both of them.

**Year:**

M.Sc. (Tech.) 1

**Period:**

2-3

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, D.Sc. (Tech.) Juha Pyrhönen

**Aims:**

Upon completion of the course the student will be able to: 1. understand the role of electrical drives, 2. understand different torque producing principles in different machines, 3. model and simulate a DC motor drive, 4. describe the principles of scalar, vector and direct torque control of rotating field machines, 5. define and understand the functioning of the most important power electronic converters, 6. discuss the principles of PWM in general, space vector modulation and DTC, 7. model the behaviour of permanent magnet synchronous machine by using vector equivalent circuits and vector diagrams, 8. understand synchronous machine control in details, 9. understand synchronous reluctance machine control in details, 10. understand the role of induction machine and its control in details, 11. know the switched reluctance machine control principles, 12. discuss the adverse effects of PWM systems on motor behaviour and the wave nature of the motor cable. Mastering the course material well gives the student comprehensive understanding of the basics of electrical drives and wide possibilities to work in the field. This is the course for drives professionals.

**Contents:**

Theory of electric motor drives, operation and vector equivalent circuits. Synchronous machine drives, asynchronous machine drives, synchronous reluctance machine drives, permanent magnet synchronous machine drives, switched reluctance motor drives. Torque production in different machines. Power electronic converters suitable for motor and generator drives. Scalar control, vector control, direct flux linkage control and direct torque control (DTC). Motor cable wave nature, bearing currents. Applying the principles for practical electrical machine types.

**Teaching Methods:**

Lectures 24 h, tutorials 24 h, 2nd period. Lectures 24 h, tutorials 24 h, 3rd period. Independent study including homework tasks 109 h. Examination 3 h.
Total workload 208 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

Yes

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, written examination 100 %.
OR Pass/fail via good enough independent homework.

**Course Materials:**

Lecture material in Moodle.
The course is based on the book: Pyrhönen, Hrabovcova, Semken: “Electrical Machine Drives Control: An Introduction”, published by John Wiley et Sons 2016

**Prerequisites:**

The students are recommended to have completed the courses BL30A0000 Electric Circuits, BL10A0100 Basics of Electric Engineering, BL30A0200 Laboratory Course in Electrical Engineering, BL30A0500 Introduction to Electrical Drives and BL30A0800 Electromagnetic Components and to have attended the course BL30A0400 Design of an Electrical Machine.

**Places for exchange-students? (Yes, number/No):**

15–

**Places for Open University Students?(Yes, number/No):**

max 5

**BL40A2810: Automation, 6 cr**

**Validity:** 01.08.2017 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Tuomo Lindh, Jan-Henri Montonen

**Year:**

M.Sc. (Tech.) 1

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Associate professor, D.Sc. (Tech.) Tuomo Lindh

**Aims:**

Upon completion of the course the student will be able to: 1. apply automation and digital control theory to practical implementations, 2. use the analog and digital communication techniques applied to automation, 3. apply fieldbuses, 4. formulate a dynamic system model
of motor drives 5. Simulate servo motor driven mechatronic systems, 6. construct controllers and models of dynamic systems using IEC61131-3 and C programming languages, 7. select a proper controller structure, 8. work in a group solving automation and control problems.

**Contents:**

IEC61131-3 programming languages, Feedback devices, Automation hardware and software. Fieldbuses. Basics of servo drive dynamics, Utilizing Simulink models in PLC systems. C/C++ languages in PLC systems. HMI, OPC, IoT in automation. Introduction to safety in automation.

**Teaching Methods:**

Lectures 14 h, exercises 14 h, 1st period.
Lectures 14 h, exercises 14 h, 2nd period.
Independent study: project work 35 h, laboratory exercises 21h
preparation for examination 40 h, examination at Moodle 4 h.
Total workload 156 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

Yes

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, examination 40 %. Project work 60%.

**Course Materials:**

Presentation slides at Moodle.
Karl-Heinz John, Michael Tiegelkamp.IEC 61131-3: Programming Industrial Automation Systems.e-ISBN 978-3-642-12015-2.

**Prerequisites:**

Basics of programming.

**Places for exchange-students? (Yes, number/No):**

Yes, 10.

**Places for Open University Students?(Yes, number/No):**

This course has 1-10 places for open university students. More information on the web site for open university instructions.

**SaDPoEI: Power Electronics, 19 cr**

**Validity:** 01.08.2017 -
**Form of study:**
**Type:** Study module
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F

No course descriptions.

*Elective module 19 ECTS cr.*

**BL20A0100: Thermal Design of an Electric Device, 3 cr**

**Validity:** 01.08.2007 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Janne Nerg

**Note:**

The course is suitable for distance learning.

**Year:**

M.Sc. (Tech.) 1

**Period:**

3

**Teaching Language:**

Finnish

**Teacher(s) in Charge:**

Associate professor, D.Sc. (Tech.) Janne Nerg

**Aims:**

Upon completion of the course the student will be able to 1. perform thermal design of a simple electronic device, 2. describe the heat transfer mechanisms and 3. analytically calculate temperature distribution of an electronic device.

**Contents:**

Heat transfer mechanisms, cooling methods of electronic devices, the effect of the operation temperature on the performance of an electronic device, thermal resistance networks, numerical calculation methods in thermal engineering.

**Teaching Methods:**

Lectures 14 h, exercises 14 h, home assignments, 3rd period. Examination or continuous assesment. Course is suitable for distance learning. Total workload 78 h.

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0–5, examination or continuous assesment 100 %.

**Course Materials:**

Course material is found from Moodle.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

max 5

### BL30A0600: Power Electronics, 6 cr

**Validity:** 01.08.2007 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Lasse Laurila

**Note:**

The course is suitable for distance learning.
Course has examination in Examination schedule, but it is not traditional paper exam. The exam will be done with computer.

**Year:**

M.Sc. (Tech.) 1

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Associate professor, D.Sc. (Tech.) Lasse Laurila

**Aims:**

Upon completion of the course the student will be able to: 1. demonstrate good general knowledge of the different basic main circuits in modern power electronics, 2. describe the features and functions of different rectifiers, switch-mode converters and inverters, 3. calculate and simulate typical design tasks of the aforementioned circuits, 4. describe the joint operation of static converters and loads as well as the network interferences caused by converters and alternatives to reduce these interferences.

**Contents:**

Operation of the main circuits of different power converters: rectifiers (single and three-phase), DC-DC switch mode converters and power supplies (buck, boost, buck-boost, flyback, forward), inverters (single and three-phase), resonance converters (ZVS, ZCS). Characteristics and operation. Pulse width modulation (PWM). Harmonic components. Simulation of power electronic circuits

(simulation tools used: PSpice and Matlab/Simulink, calculations on Mathcad, Excel). Possible extra assignments to gather extra points to the exam.

**Teaching Methods:**

Combined lectures and tutorials, 28 h, 1st period. Combined lectures and tutorials, 28 h, 2nd period. Moodle-examination, 3 h. Independent study 97 h. The course is suitable for distance learning.
Total workload 156 h.

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

Yes

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, examination 100 %. 75 % of tutorial tasks passed or 75 % active presence in tutorials. Possible extra assignments to gather extra points to the exam.

**Course Materials:**

Mohan, Undeland, Robbins: Power Electronics, converters, applications, and design. Chapters 1 to 18.
Course material in Moodle.

**Prerequisites:**

Recommended: BL30A0000 Electric Circuits. Integration and derivation (esp. sine and cosine functions).
FFT. Laplace transforms. Basic software skills with Excel, Word.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

max 5

### BL30A0800: Electromagnetic Components, 3 cr

**Validity:** 01.08.2007 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Janne Nerg

**Note:**

The course is suitable for distance learning.

**Year:**

M.Sc. (Tech.) 1

**Period:**

1

**Teaching Language:**

Finnish

**Teacher(s) in Charge:**

Associate professor, D.Sc. (Tech.) Janne Nerg

**Aims:**

Upon completion of the course the student will be able to: 1. design simple transformers and inductors, 2. name and describe magnetic core materials, 3. describe the different loss mechanisms, 4. explain the non-linearities of inductors and transformers at different frequencies, 5. minimise the transformer leakage inductance.

**Contents:**

Faraday's induction law, Ampère's law, operation principle of a transformer and an inductor, non-linearities of electromagnetic components, magnetic materials, iron losses and copper losses.

**Teaching Methods:**

14 h of lectures, 14 h of tutorials, 1st period. Home assignments. Examination or continuous assesment. The course is suitable for distance learning.
Total workload 78 h.

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, examination or continuous assesment 100 %.

**Course Materials:**

Course material is found from Moodle.

**Prerequisites:**

BL30A0300 Electromagnetism attended.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

max 5

### BL30A0901: Power Electronic Components, 5 cr

**Validity:** 01.08.2016 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Lasse Laurila

**Note:**

The course is suitable for distance learning.
Course has examination in Examination schedule, but it is not traditional paper exam. The exam will be done with computer.

**Year:**

M.Sc. (Tech.) 1

**Period:**

3-4

**Teaching Language:**

English

**Teacher(s) in Charge:**

Lasse Laurila, D.Sc. (Tech.), Associate professor

**Aims:**

After the course the student can: 1. describe the properties, operation and suitable applications of different power electronic devices, passive components and electrical energy storages. 2. calculate the losses of the device and design suitable cooling and protection. 3. Simulate and analyse switching phenomena of power electronic components.

**Contents:**

Basic semiconductor physics, pn-junction, power semiconductor devices, passive components, mobile power electronics, electrical energy storages (batteries, supercapacitors). Operation principles of power electronic switches, switching phenomena, losses, applications. Manufacturing methods, gate and base drive circuits, cooling methods, protection methods. Simulation of power electronic components. Possible extra assignments to gather extra points to the exam.

**Teaching Methods:**

Combined lectures and tutorials, 28 h, 3. period. Combined lectures and tutorials, 28 h, 4th period. Moodle examination 3 h. Independent study 71 h. The course is suitable for distance learning. Total workload 130 h.

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

Yes

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, examination 100 %. 75 % of tutorial tasks passed or 75 % active presence in tutorials. Possible extra assignments to gather extra points to the exam.

**Course Materials:**

Mohan, Undeland, Robbins: Power Electronics, converters, applications, and design. Chapters 19-29.
Course material in Moodle.
Recommended to follow also additional material listed in Moodle and lecture materials.

**Prerequisites:**

BL30A0000 Electric Circuits. Integration and derivation.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

max 5

### BL50A0600: Electromagnetic Compatibility in Power Electronics, 2 cr

**Validity:** 01.08.2007 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Juhamatti Korhonen, Pertti Silventoinen

**Note:**

The course is suitable for distance learning.

**Year:**

M.Sc. (Tech.) 2

**Period:**

2

**Teaching Language:**

English

**Teacher(s) in Charge:**

D.Sc. (Tech.) Juhamatti Korhonen

**Aims:**

Upon completion of the course the student will be able to:
1. describe the coupling mechanisms of electromagnetic interference in power electronics,
2. describe the most significant sources of electromagnetic emissions in power electronic systems,
3. provide suitable filter solutions for common-mode filtering, differential-mode filtering, du/dt filtering and harmonics filtering.

**Contents:**

Power electronics as an interference source, network harmonics, reflection phenomena of cables, conductive RF interference, interference radiation of power electronics, filtering techniques of conductive interference.

**Teaching Methods:**

14 h of lectures, 2st period. Moodle examination, weekly quizzes. Independent work 38 h. Online course.
Total workload 52 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

Yes

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, Moodle examination 70 %, weekly quizzes 30 %.

**Course Materials:**

To be announced in class.

**Prerequisites:**

Recommended: Basic knowledge of electromagnetism and electromagnetic fields.

**Places for exchange-students? (Yes, number/No):**

15–

**Places for Open University Students?(Yes, number/No):**

max 10

**SaDDoEm: Design of Electrical Machines, 24 cr**

**Validity:** 01.08.2017 -
**Form of study:**
**Type:** Study module
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F

No course descriptions.

*Elective module 24 ECTS cr.*

**BL20A0100: Thermal Design of an Electric Device, 3 cr**

**Validity:** 01.08.2007 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Janne Nerg

**Note:**
The course is suitable for distance learning.
**Year:**
M.Sc. (Tech.) 1
**Period:**
3
**Teaching Language:**
Finnish
**Teacher(s) in Charge:**
Associate professor, D.Sc. (Tech.) Janne Nerg
**Aims:**
Upon completion of the course the student will be able to 1. perform thermal design of a simple electronic device, 2. describe the heat transfer mechanisms and 3. analytically calculate temperature distribution of an electronic device.
**Contents:**
Heat transfer mechanisms, cooling methods of electronic devices, the effect of the operation temperature on the performance of an electronic device, thermal resistance networks, numerical calculation methods in thermal engineering.
**Teaching Methods:**
Lectures 14 h, exercises 14 h, home assignments, 3rd period. Examination or continuous assesment. Course is suitable for distance learning. Total workload 78 h.
**Examination in Examination schedule (Yes/No):**
Yes
**Examination in Moodle (Yes/No):**
No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0–5, examination or continuous assesment 100 %.

**Course Materials:**

Course material is found from Moodle.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

max 5

### BL30A0400: Design of an Electrical Machine, 6 cr

**Validity:** 01.08.2007 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Juha Pyrhönen

**Year:**

M.Sc. (Tech.) 1

**Period:**

1

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, D.Sc. (Tech.) Juha Pyrhönen

**Aims:**

Upon completion of the course the student will be able to: 1. perform a basic design of a rotating electrical machine, 2. design the simplest winding arrangements and other components of the machine, 3. explain the torque production process in electrical machines, 4. calculate the main data (equivalent circuit parameters) of an electrical machine from machine geometric and winding designs, 5. List and apply the most important materials used in magnetic circuits and windings, 6. model the machine with an equivalent circuit, 7. compare machine designs with each other by using the per unit presentation of machines, 8. use phasor diagrams in the machine analysis, 9. discuss the problems of insulation systems and heat transfer.

**Contents:**

Electromagnetic principles used in machine design, the magnetic circuit of an electric machine, the windings of an electric machine, impacts of the structure of the electric motor on the motor characteristics, calculation of the parameters of an equivalent circuit from the dimensions of the machine (resistances, inductances), effective-value phasor diagrams for different machine types, principles of electric machine design, insulation materials and systems heat transfer.

**Teaching Methods:**

Lectures 24 h, tutorials 24 h, design assignment of an electric machine 48 h and other independent studies 57 h, exam 3 h 1st period.
Total workload 156 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, written examination 100 %. Satisfactorily completed assignment required.
Or: The course can be passed with the grade “Accepted” by satisfactory completion of the homework and the design assignment.

**Course Materials:**

Lecture materials in Moodle.
The course is based on suitable parts of Pyrhönen, Jokinen, Hrabovcova: Design of Rotating Electrical Machines

**Prerequisites:**

Students are recommended to have good knowledge in electromagnetism, completed BL30A0000 Electric Circuits, BL10A0100 Basics of Electric Engineering.

**Places for exchange-students? (Yes, number/No):**

15–

**Places for Open University Students?(Yes, number/No):**

max 5

### BL30A0800: Electromagnetic Components, 3 cr

**Validity:** 01.08.2007 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Janne Nerg

**Note:**

The course is suitable for distance learning.

**Year:**

M.Sc. (Tech.) 1

**Period:**

1

**Teaching Language:**

Finnish

**Teacher(s) in Charge:**

Associate professor, D.Sc. (Tech.) Janne Nerg

**Aims:**

Upon completion of the course the student will be able to: 1. design simple transformers and inductors, 2. name and describe magnetic core materials, 3. describe the different loss mechanisms, 4. explain the non-linearities of inductors and transformers at different frequencies, 5. minimise the transformer leakage inductance.

**Contents:**

Faraday’s induction law, Ampère’s law, operation principle of a transformer and an inductor, non-linearities of electromagnetic components, magnetic materials, iron losses and copper losses.

**Teaching Methods:**

14 h of lectures, 14 h of tutorials, 1st period. Home assignments. Examination or continuous assesment. The course is suitable for distance learning.
Total workload 78 h.

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, examination or continuous assesment 100 %.

**Course Materials:**

Course material is found from Moodle.

**Prerequisites:**

BL30A0300 Electromagnetism attended.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

max 5

### BL30A1001: Electrical Drives, 8 cr

**Validity:** 01.08.2010 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Juha Pyrhönen

**Note:**

The first part (2nd period) will be studied in collaboration with BL30A1020 Electrical Drives, Compact. Common lectures, exercises and homework. The student may participate either in “Electrical Drives, Compact” or “Electrical Drives”, not in both of them.

**Year:**

M.Sc. (Tech.) 1

**Period:**

2-3

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, D.Sc. (Tech.) Juha Pyrhönen

**Aims:**

Upon completion of the course the student will be able to: 1. understand the role of electrical drives, 2. understand different torque producing principles in different machines, 3. model and

simulate a DC motor drive, 4. describe the principles of scalar, vector and direct torque control of rotating field machines, 5. define and understand the functioning of the most important power electronic converters, 6. discuss the principles of PWM in general, space vector modulation and DTC, 7. model the behaviour of permanent magnet synchronous machine by using vector equivalent circuits and vector diagrams, 8. understand synchronous machine control in details, 9. understand synchronous reluctance machine control in details, 10. understand the role of induction machine and its control in details, 11. know the switched reluctance machine control principles, 12. discuss the adverse effects of PWM systems on motor behaviour and the wave nature of the motor cable. Mastering the course material well gives the student comprehensive understanding of the basics of electrical drives and wide possibilities to work in the field. This is the course for drives professionals.

**Contents:**

Theory of electric motor drives, operation and vector equivalent circuits. Synchronous machine drives, asynchronous machine drives, synchronous reluctance machine drives, permanent magnet synchronous machine drives, switched reluctance motor drives. Torque production in different machines. Power electronic converters suitable for motor and generator drives. Scalar control, vector control, direct flux linkage control and direct torque control (DTC). Motor cable wave nature, bearing currents. Applying the principles for practical electrical machine types.

**Teaching Methods:**

Lectures 24 h, tutorials 24 h, 2nd period. Lectures 24 h, tutorials 24 h, 3rd period. Independent study including homework tasks 109 h. Examination 3 h.
Total workload 208 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

Yes

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, written examination 100 %.
OR Pass/fail via good enough independent homework.

**Course Materials:**

Lecture material in Moodle.
The course is based on the book: Pyrhönen, Hrabovcova, Semken: “Electrical Machine Drives Control: An Introduction”, published by John Wiley et Sons 2016

**Prerequisites:**

The students are recommended to have completed the courses BL30A0000 Electric Circuits, BL10A0100 Basics of Electric Engineering, BL30A0200 Laboratory Course in Electrical Engineering, BL30A0500 Introduction to Electrical Drives and BL30A0800 Electromagnetic Components and to have attended the course BL30A0400 Design of an Electrical Machine.

**Places for exchange-students? (Yes, number/No):**

15–

**Places for Open University Students?(Yes, number/No):**

max 5

### BL30A1200: Numerical Methods in Electromagnetism, 4 cr

**Validity:** 01.08.2007 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Janne Nerg

**Year:**

M.Sc. (Tech.) 2

**Period:**

3

**Teaching Language:**

English

**Teacher(s) in Charge:**

Associate professor, D.Sc. (Tech.) Janne Nerg

**Aims:**

Upon completion of the course the student will be able to model and analyse electrical machines using commercial finite element based calculation software.

**Contents:**

The fundamentals of the element method, boundary conditions, modelling of materials, post-processing of results. Iron loss models. Eddy current problems, utilisation of circuit model in calculation.

**Teaching Methods:**

28 h of supervised tutorials. 3rd period. Self study: assignment and report 76 h.
Total workload 104 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

Course requirements: participation in tutorials and a satisfactorily completed assignment. 0-5, assignment 100 %.

**Course Materials:**

Course material in Moodle.

**Prerequisites:**

BL30A0500 Introduction to Electrical Drives and BL30A0400 Design of an Electrical Machine.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

max 5

**SaDECS: Electric Conversion Systems, 24 cr**

**Validity:** 01.08.2017 -

**Form of study:**

**Type:** Study module
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F

No course descriptions.

*Elective module 20 ECTS cr.*

**BL30A0600: Power Electronics, 6 cr**

**Validity:** 01.08.2007 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Lasse Laurila

**Note:**

The course is suitable for distance learning.
Course has examination in Examination schedule, but it is not traditional paper exam. The exam will be done with computer.

**Year:**

M.Sc. (Tech.) 1

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Associate professor, D.Sc. (Tech.) Lasse Laurila

**Aims:**

Upon completion of the course the student will be able to: 1. demonstrate good general knowledge of the different basic main circuits in modern power electronics, 2. describe the features and functions of different rectifiers, switch-mode converters and inverters, 3. calculate and simulate typical design tasks of the aforementioned circuits, 4. describe the joint operation of static converters and loads as well as the network interferences caused by converters and alternatives to reduce these interferences.

**Contents:**

Operation of the main circuits of different power converters: rectifiers (single and three-phase), DC-DC switch mode converters and power supplies (buck, boost, buck-boost, flyback, forward), inverters (single and three-phase), resonance converters (ZVS, ZCS). Characteristics and operation. Pulse width modulation (PWM). Harmonic components. Simulation of power electronic circuits (simulation tools used: PSpice and Matlab/Simulink, calculations on Mathcad, Excel). Possible extra assignments to gather extra points to the exam.

**Teaching Methods:**

Combined lectures and tutorials, 28 h, 1st period. Combined lectures and tutorials, 28 h, 2nd period. Moodle-examination, 3 h. Independent study 97 h. The course is suitable for distance learning.
Total workload 156 h.

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

Yes

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, examination 100 %. 75 % of tutorial tasks passed or 75 % active presence in tutorials. Possible extra assignments to gather extra points to the exam.

**Course Materials:**

Mohan, Undeland, Robbins: Power Electronics, converters, applications, and design. Chapters 1 to 18.
Course material in Moodle.

**Prerequisites:**

Recommended: BL30A0000 Electric Circuits. Integration and derivation (esp. sine and cosine functions).
FFT. Laplace transforms. Basic software skills with Excel, Word.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

max 5

### BL30A1020: Electrical Drives, Compact, 4 cr

**Validity:** 01.08.2017 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Juha Pyrhönen

**Note:**

The course has common lectures exercises and homework with the first part of the course BL30A1001 Electrical Drives.
The student may participate either in “Electrical Drives, Compact” or “Electrical Drives”, not in both of them.

**Year:**

M.Sc. (Tech.) 1

**Period:**

2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, D.Sc. (Tech.) Juha Pyrhönen

**Aims:**

Upon completion of the course the student will be able to: 1. understand the role of electrical drives, 2. understand different torque producing principles in different machines, 3. model and simulate a DC motor drive, 4. describe the principles of scalar, vector and direct torque control of

rotating field machines, 5. define the most important power electronic converters, 6. discuss the principles of PWM, space vector modulation and DTC. 7. model the behaviour of permanent magnet synchronous machine by using vector equivalent circuits and vector diagrams.

**Contents:**

Theory of electric motor drives, operation and vector equivalent circuits. Torque production in different machines. Power electronic converters suitable for motor and generator drives. Scalar control, vector control, direct flux linkage control and direct torque control (DTC). Permanent magnet synchronous machine drives.

**Teaching Methods:**

Common lectures 24 h, tutorials 24 h, 2nd period. Independent study including homework 56 h. Total workload 104 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

Pass/fail. The course can be passed with via good enough independent homework.

**Course Materials:**

Lecture material in Moodle
The course is based on chapters 1-7 and 9 of the book: Pyrhönen, Hrabovcova, Semken, “Electrical Machine Drives Control: An Introduction”, published by John Wiley et Sons 2016

**Prerequisites:**

The students are recommended to have completed the courses BL30A0000 Electric Circuits, BL10A0100 Basics of Electric Engineering, BL30A0200 Laboratory Course in Electrical Engineering, BL30A0500 Introduction to Electrical Drives and BL30A0800 Electromagnetic Components and to have attended the course BL30A0400 Design of an Electrical Machine.

**Places for exchange-students? (Yes, number/No):**

15–

**Places for Open University Students?(Yes, number/No):**

max 5

### BL40A2401: Electrical Engineering in Wind and Solar Systems, 6 cr

**Validity:** 01.08.2013 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Olli Pyrhönen

**Note:**

The course is suitable for distance learning.

**Year:**

M.Sc. (Tech.) 1

**Period:**

3-4

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, D.Sc. (Tech.) Olli Pyrhönen

**Aims:**

Upon completion of the course the student can: 1. Describe the functional principle of wind or solar power plant 2. describe and identify electrotechnical components and system layouts in wind and solar power plants, 3. dimension the electrotechnical components in wind /solar power plants, 4. describe and analyse the control systems of wind/solar power plants, 5. describe and analyse the grid connection requirements of wind/solar power plants, 6. Describe and analyse the interaction between the grid and wind/solar power plant in different abnormal situations.

**Contents:**

Drive train technologies in wind power systems, Permanent magnet synchronous generator drive train, double-fed induction generator drive train, electric conversion in PV solar power, system topologies and power electronics solutions in small and utility scale PV solar plants. Control of a wind power plant, control of a solar power plant, technical requirements in grid connection, voltage and reactive power control in wind/solar power plants, electrical protection of wind/solar power plants. Grid codes, other international regulations and standards in wind and solar power systems. Introduction to grid connection modelling software.

**Teaching Methods:**

Lectures 28 h, exercises 14 h, demolectures 6 h, 4-6 h, assignment 62 h, independent working 37 h, examination 3h. Total workload 156 h. The course is suitable for distant learning. In distant learning, exersices are replaced by homeworks.
Total workload 156 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

Yes

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, examination 50 %, homeworks 25 %,  assignment 25 %

**Course Materials:**

Material handed out in class.

**Prerequisites:**

Previous knowledge of electrical engineering required. Basics of electrical machines and/or transmission of electricity recommended.

**Number of exercise groups where enrollment is in WebOodi (Number/Leave empty):**

1

**Places for exchange-students? (Yes, number/No):**

max 10

**Places for Open University Students?(Yes, number/No):**

No

## BL40A2910: Electric Energy Conversion Systems, 4 cr

**Validity:** 01.08.2017 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Olli Pyrhönen, Pasi Peltoniemi

**Year:**

M.Sc. (Tech.) 2

**Period:**

1

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, D.Sc. (Tech.) Olli Pyrhönen

**Aims:**

The student knows the most relevant electrical power conversion solutions in industrial and power system applications. He/she get knowledge of system topologies, main components and control principles in the selected application fields. He/she is able to make basic system design, component selection and dimensioning according to application specifications.

**Contents:**

Marine vessel power system technology, system layout, components and control principles. Electric vehicle and hybrid work machine power system technology, components and control principles. Industrial drive applications, components and control principles. Electrochemical conversion system applications, components and control principles. Examples of different applications. Component selection and dimensioning. Examples of existing system solutions in different application fields.

**Teaching Methods:**

14 hours of lectures, 1st period. 6-7 h Visiting lectures from industry, 2nd period. Assignment 1st and 2nd period 40 h.
Written examination 3 h. Independent working 40 h.
Total workload 104 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

Yes

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5. Written examination (70%), assignment (30%).

**Course Materials:**

Lecture material.

**Prerequisites:**

Electrical Drives, Compact
Power Electronics
Säätötekniikan perusteet /Introduction to Control Engineering

**Places for exchange-students? (Yes, number/No):**

Yes, max 10

**Places for Open University Students?(Yes, number/No):**

No

**SaDSoEc: Solar Economy, 18 - 21 cr**

**Validity:** 01.08.2017 -
**Form of study:**
**Type:** Study module
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F

No course descriptions.

*Elective module 18-21 ECTS cr.*

**BL20A1300: Energy Resources, 6 cr**

**Validity:** 01.08.2014 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Michael Child, Christian Breyer

**Year:**

M.Sc. (Tech.) 1

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, D.Sc. (Tech.) Christian Breyer

**Aims:**

Upon completion of the course the student will be able to: 1. Identify the constraints and potentials of all relevant energy sources in a global context. 2. Describe all relevant energy conversion technologies on the basis of their energy resource. 3. Analyse the principal structure of future energy systems on the basis of energy resource characteristics. 4. Describe the special relevance of wind energy and solar energy in the ongoing energy transformation.

**Contents:**

The course provides an overview on the availability of energy resources and related emissions and techno-economic maturity of related energy conversion technologies, which induces a fundamental structure for the future energy system and the related energy transformation pathway. The course comprises the main energy resources for the current and future energy system: crude oil,natural gas, coal, uranium, hydro power, bioenergy, solar energy, wind energy, geothermal energy, and ocean energy. These energy resources have different theoretical, technical and economic potentials as well as geographic variations in availability. The resources also differ considerably in the impact of the emissions related to the respective energy conversion technologies being relevant for the degree of sustainability. A broad variety of energy conversion technologies at different levels of maturity are used for utilizing the resources.

**Teaching Methods:**

Lectures 14 h, exercises 14 h, 1st period. Lectures 14 h,exercises 14 h, 2nd period. Examination 3h. Independent study 97 h.
Total workload 156 h.

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, examination 100%.

**Course Materials:**

Material handed out in class and made available on Moodle.

**Places for exchange-students? (Yes, number/No):**

15–

**Places for Open University Students?(Yes, number/No):**

max 5

### BL20A1400: Renewable Energy Technology, 6 cr

**Validity:** 01.08.2015 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Christian Breyer, Michael Child

**Year:**

M.Sc. (Tech.) 1

**Period:**

3-4

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, D.Sc. (Tech.) Christian Breyer

**Aims:**

Upon completion of the course the student will be able to: 1. Identify the major renewable energy (RE) conversion technologies, mainly converting resources to electricity. 2. Describe the major characteristics of the technologies, in particular applications, efficiency, economics, industrial scale and future prospects. 3. Analyse the need for storage technologies and their different fields of application based on their key technical and economic features.

**Contents:**

The course is focused on the conversion of the resources to electricity. The RE technologies discussed in the course are: wind turbines, solar photovoltaics, solar thermal electricity generation and hydro powerplants. The storage technologies covered comprise a general overview and in

particular include battery storage, pumped hydro storage and power-to-gas technologies. All technologies are classified with respect to their applications, efficiency, maturity, economics, industrial scaling and expected relevance for the ongoing energy transformation.

**Teaching Methods:**

3rd period lectures 14 h, exercises 14 h. 4thperiod lectures 14 h, exercises 14 h, examination 3 h. Independent study 97 h.
Total workload 156 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, examination 100 %

**Course Materials:**

Material handed out in class and made available on Moodle.

**Places for exchange-students? (Yes, number/No):**

15–

**Places for Open University Students?(Yes, number/No):**

max 5

### BL20A1500: Energy Scenarios, 6 cr

**Validity:** 01.08.2015 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Christian Breyer, Michael Child

**Year:**

M.Sc. (Tech.) 2

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, D.Sc. (Tech.) Christian Breyer

**Aims:**

Upon completion of the course the student will be able to: 1. Describe the sustainability requirements of future energy systems as the major guard rail for the energy transformation. 2. Analyse energy transformation scenarios and identify the key technologies and setups for sustainable energy progress. 3. Describe the energy transformation in all sectors, the major

technologies, the required transformation period and entire system cost optimization. 4. Describe the special role of power technologies for the energy transformation. 5. Recognize the difference between standard levelized cost ofenergy and total societal cost of energy.

**Contents:**

The course comprises the key elements of energy scenarios: demand, supply, cost, constraints. Energy demand is an aggregate of power, heat, cooling, mobility, agriculture and industrial energy needs. The demand has tobe matched with supply of energy fulfilling sustainability criteria, safety requirements and societal acceptance for the least cost. A complete set of demand curves, technical characteristics of all major technologies, current and projected technology costs and emission factors are taken into account for sustainable energy transformation pathway formulation. The special relevance ofwind energy and solar photovoltaics, the increasing relevance of power technologies,the role of storage technologies and the necessity of societal cost of energy are discussed in detail. Real scenarios for Finland, Europe and the World used as references.

**Teaching Methods:**

1st period lectures 14 h, exercises 14 h. 2ndperiod lectures 14 h, exercises 14 h, presentation/oral examination 1 h. Independent study 99 h. Total workload 156 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, presentation/oral examination 100 %

**Course Materials:**

Material handed out in class and made available on Moodle.

**Prerequisites:**

BL20A1300 Energy Resources and BL20A1400 Renewable Energy Technology (at least one of the two courses)

**Places for exchange-students? (Yes, number/No):**

max 15

**Places for Open University Students?(Yes, number/No):**

max 5

*LUT Summer School course, optional.*

### BL10A8400SS: Solar Economy and Smart Grids, 3 cr

**Validity:** 01.06.2014 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Jarmo Partanen, Satu Viljainen, Olli Pyrhönen, Christian Breyer

**Year:**

M.Sc. (Tech.) 1–2

**Period:**

INT. Summer School

**LUT Summer School time:**

6. – 10.8.2018

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, D.Sc. (Tech.) Christian Breyer

**Aims:**

After having passed this course the student is able to:
- understand the basic processes of solar economy and Smart Grids
- recognize the key properties of global climate challenges, solar economy, electricity market models, wind and solar power technologies, energy storage technologies and smart grid concept
- recognize the most important aspects, chances and challenges of transformation from existing energy systems to sustainable energy systems.

**Contents:**

During the course the student will become familiar with the properties and application areas of:
- Climate change
- Solar economy
- Wind power technology
- Solar power technology
- Energy Storage Technologies
- New electricity market
- Demand response
- Smart Grid concept.

**Teaching Methods:**

- Introductory lectures and exercises 24 h
- Team work and a limited project work 20 h
- Presentations of the results of the team work/ project work 8 h
- Independent work is needed 26 h.

Total workload 78 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

Final grade 0 –5, project work/presentation

**Course Materials:**

Lecture notes and other materials distributed during the course by email.

**Prerequisites:**

Previous studies either in electrical engineering, environmental engineering or energy engineering are recommended.

**Places for exchange-students? (Yes, number/No):**

15–

**Places for Open University Students?(Yes, number/No):**

max 5

**SaDCaA: Control and Automation, 22 cr**

**Validity:** 01.08.2017 -
**Form of study:**
**Type:** Study module
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F

No course descriptions.

*Elective module 22 ECTS cr.*

**BL40A0810: Digital Signal Processing II, 4 cr**

**Validity:** 01.08.2017 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Engineering Science
**Grading:** Study modules 0-5,P/F
**Teachers:** Antti Kosonen, Tuomo Lindh

**Year:**

M.Sc. (Tech.) 1

**Period:**

3-4

**Teaching Language:**

English

**Teacher(s) in Charge:**

Associate Professor, D.Sc. Antti Kosonen

**Aims:**

Upon completion of the course the student will be able to: 1. describe the practical implementation of digital filters, 2. describe the finite word length effects on the frequency response and operation of a filter, 3. in order to minimize these effects, transform the direct-form implementations into a more beneficial format with respect to the finite word length effects and do the required scaling, 4. describe the representations of fixed and floating point numbers, 5. design FIR and IIR filters with the ready-made software and describe the basics of design methods, 6. know applications of optimal and adaptive filters, 7. implement median filters.

**Contents:**

The finite word length effects and elimination of these effects. Alternative structures for discrete-time systems and their programming implementation. Computer-aided design of digital filters. Decimation and interpolation. Median filters. Optimal and adaptive filters.

**Teaching Methods:**

14 h of lectures and 14 h of tutorials, 1st period.14 h of lectures, 14 h of tutorials, 30 h of assignment with seminar, 2nd period. Written examination. Independent study 18 h.
Total workload 104 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

Examination 60%, assignment 40%.

**Course Materials:**

Proakis, J.G.and Manolakis, D.G.: Digital Signal Processing, Principles,Algorithms, and Applications.
Lecture slides.
Luukko, J.: Digitaalinen suodatus (luentomoniste)

**Prerequisites:**

BL40A0401 Signaalien digitaalinen käsittely I (Digital Signal Processing I) or corresponding knowledge.

**Places for exchange-students? (Yes, number/No):**

max 10

**Places for Open University Students?(Yes, number/No):**

max 15

### BL40A1202: Digital Control Design, 6 cr

**Validity:** 01.08.2017 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Olli Pyrhönen, Pasi Peltoniemi, Rafal Jastrzebski

**Year:**

M.Sc. (Tech.) 1

**Period:**

1-2

**Teaching Language:**

Finnish and English

**Teacher(s) in Charge:**

Professor Olli Pyrhönen

**Aims:**

Upon completion of the course students  are able to design and implement a digital control system for industrial application independently. The necessary skills are dynamic plant modeling, system design, control synthesis, system simulation and digital controller implementation in an industrial control platform.

**Contents:**

The teaching approach on this course is practical control design and implementation for different applications. The first half of the course introduces design of advanced control methods for different application. The application topics may change yearly. The following topics are included, plant modelling, different state-space and transfer functions algorithms for SISO and MIMO systems, digital controller synthesis, system simulation, controller programming and testing. In

the second half of the course every student will design, program and test a controller using an industrial controller platform and a laboratory equipments.

**Teaching Methods:**

28 h interactive lectures in computer class room, 1. period, 14 h control system development project tutorial lectures in computer class room, laboratory working 6 h, exam 3 h, independent studies.
Total workload 156 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

Yes

**Examination in Exam (Yes/No):**

No

**Assessment:**

Examination 60%, control system design project 40%.

**Course Materials:**

Lecture script and handout, more detailed material in the text books:
Franklin G.F., Powell J.D., Workman M.L., Digital Control of Dynamic Systems, Addison-Wesley, 1998,
Kuo B., Digital Control Systems, 2nd ed., Oxford University Press, 1992,
Åström K.J., Wittenmark B., Computer Controlled Systems, 3rd ed., Prentice Hall, 1997, 557 p.

**Prerequisites:**

BL40A0200 Säätötekniikan perusteet A or BL40A0300 - Säätötekniikan perusteet B
BL40A0501 - Digitaalisäädön perusteet

**Places for exchange-students? (Yes, number/No):**

max 10

**Places for Open University Students?(Yes, number/No):**

No

### BL40A2700: System Engineering Project Work, 6 cr

**Validity:** 01.08.2013 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Olli Pyrhönen, Jero Ahola, Jan-Henri Montonen, Tuomo Lindh

**Year:**

M.Sc. (Tech.) 2

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Associate professor. D.Sc. (Tech.) Tuomo Lindh, professor, D.Sc. (Tech.) Olli Pyrhönen, professor, D. Sc. (Tech.) Jero Ahola

**Aims:**

Upon completion of the course the student is prepared to work in a R&D team as a system engineer. The student is able to manage the project scheduling and project roles, and share responibilities among group members. The student can produce a tecnical documentation.

**Contents:**

The students will analyse and design a selected electrical energy conversion system in the field of industrial electrical drives, renewable energy conversion or motion control system. The topics are linked to an on-going research project or industrial co-operation in the above-mentioned fields. The project work includes several partly alternative system engineering tasks, such as project planning, preliminary system design, dynamic modelling and simulation, component dimensioning, electrical dimensioning, control design, automation design, control software design and project documentation. The tasks are project dependent and will be defined in the project plan.
Introduction to a system engineering approach in technical projects. Project documentation, different tasks in project work, project planning and implementation, example projects, execution of system engineering tasks, project documentation and presentation. The main result of the project work is technical project documentation including an overall description and the results of agreed system engineering tasks.

**Teaching Methods:**

Introductory lecture, independent group working (3-5 students in one group), individual tasks within the group work, project group meetings with supervisors, writing project documentation, project presentation and demonstration. The project work topics will be defined in detail at the beginning of the course.
Total workload 156 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, Project work that includes management of the project, system design, problem solving, designs, documentation and presentation.
Also the project phases from setting the goals to the design, implementation and utilization are graded.

**Course Materials:**

Project related material.
Jürg Kuster, Eugen Huber, Robert Lippmann, Alphons Schmid, Emil Schneider, Urs Witschi,Roger Wüst. Project Management Handbook, ISBN 978-3-662-45373-5.

**Prerequisites:**

A majority of the M.Sc. (El. Eng.) studies should be completed before participation.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

This course has 1-5 places for open university students. More information on the web site for open university instructions.

**BL40A2810: Automation, 6 cr**

**Validity:** 01.08.2017 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Tuomo Lindh, Jan-Henri Montonen

**Year:**

M.Sc. (Tech.) 1

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Associate professor, D.Sc. (Tech.) Tuomo Lindh

**Aims:**

Upon completion of the course the student will be able to: 1. apply automation and digital control theory to practical implementations, 2. use the analog and digital communication techniques applied to automation, 3. apply fieldbuses, 4. formulate a dynamic system model
of motor drives 5. Simulate servo motor driven mechatronic systems, 6. construct controllers and models of dynamic systems using IEC61131-3 and C programming languages, 7. select a proper controller structure, 8. work in a group solving automation and control problems.

**Contents:**

IEC61131-3 programming languages, Feedback devices, Automation hardware and software. Fieldbuses. Basics of servo drive dynamics, Utilizing Simulink models in PLC systems. C/C++ languages in PLC systems. HMI, OPC, IoT in automation. Introduction to safety in automation.

**Teaching Methods:**

Lectures 14 h, exercises 14 h, 1st period.
Lectures 14 h, exercises 14 h, 2nd period.
Independent study: project work 35 h, laboratory exercises 21h
preparation for examination 40 h, examination at Moodle 4 h.
Total workload 156 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

Yes

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, examination 40 %. Project work 60%.

**Course Materials:**

Presentation slides at Moodle.
Karl-Heinz John, Michael Tiegelkamp.IEC 61131-3: Programming Industrial Automation Systems.e-ISBN 978-3-642-12015-2.

**Prerequisites:**

Basics of programming.

**Places for exchange-students? (Yes, number/No):**

Yes, 10.

**Places for Open University Students?(Yes, number/No):**

This course has 1-10 places for open university students. More information on the web site for open university instructions.

**SaDEmSy: Embedded Systems, 24 cr**

**Validity:** 01.08.2017 -
**Form of study:**
**Type:** Study module
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F

No course descriptions.

*Elective module 24 ECTS cr.*

**BL40A0810: Digital Signal Processing II, 4 cr**

**Validity:** 01.08.2017 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Engineering Science
**Grading:** Study modules 0-5,P/F
**Teachers:** Antti Kosonen, Tuomo Lindh

**Year:**
M.Sc. (Tech.) 1
**Period:**
3-4
**Teaching Language:**
English
**Teacher(s) in Charge:**
Associate Professor, D.Sc. Antti Kosonen
**Aims:**
Upon completion of the course the student will be able to: 1. describe the practical implementation of digital filters, 2. describe the finite word length effects on the frequency response and operation of a filter, 3. in order to minimize these effects, transform the direct-form implementations into a more beneficial format with respect to the finite word length effects and do the required scaling, 4. describe the representations of fixed and floating point numbers, 5. design FIR and IIR filters with the ready-made software and describe the basics of design methods, 6. know applications of optimal and adaptive filters, 7. implement median filters.
**Contents:**
The finite word length effects and elimination of these effects. Alternative structures for discrete-time systems and their programming implementation. Computer-aided design of digital filters. Decimation and interpolation. Median filters. Optimal and adaptive filters.
**Teaching Methods:**
14 h of lectures and 14 h of tutorials, 1st period.14 h of lectures, 14 h of tutorials, 30 h of assignment with seminar, 2nd period. Written examination. Independent study 18 h.
Total workload 104 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

Examination 60%, assignment 40%.

**Course Materials:**

Proakis, J.G.and Manolakis, D.G.: Digital Signal Processing, Principles,Algorithms, and Applications.
Lecture slides.
Luukko, J.: Digitaalinen suodatus (luentomoniste)

**Prerequisites:**

BL40A0401 Signaalien digitaalinen käsittely I (Digital Signal Processing I) or corresponding knowledge.

**Places for exchange-students? (Yes, number/No):**

max 10

**Places for Open University Students?(Yes, number/No):**

max 15

### BL40A1101: Embedded System Programming, 5 cr

**Validity:** 01.08.2017 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Jouni Vuojolainen, Tuomo Lindh, Teemu Sillanpää

**Year:**

M.Sc. (Tech.) 1

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Associate professor, D.Sc. (Tech.) Tuomo Lindh

**Aims:**

Upon completion of the course the student will be able to: 1. apply C language and its structures to embedded system programming, 2. form complex data types such as structures, unions and buffers and use these in order to maintain information of different entities (e.g. processing units), 3. control the registers of a micro controller using C-language, 4. use different PUs of a micro controller, 5. Take into use a real time operation system.

**Contents:**

Design tools, C-language in embedded system programming, utilization of a micro controller environment (registers, timers, buses, A/D conversion etc.). Typical data structures, typical program structures in real-time applications.

**Teaching Methods:**

14 h of lectures, 14 h of tutorials, 1st period. 14 h of lectures, 14 h of tutorials, 2nd period. Assignment. Written examination.
Total workload 130 h.

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, assignment 1 50 %, examination 50 %.

**Course Materials:**

Wolf, W.: Computers as components: principles of embedded computing system design. Lecture notes.

**Prerequisites:**

Basics of C language.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

This course has 1-5 places for open university students. More information on the web site for open university instructions.

### BL40A1601: Embedded System Design, 6 cr

**Validity:** 01.08.2013 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Jero Ahola, Juhamatti Korhonen

**Year:**

M.Sc. (Tech.) 1

**Period:**

3-4

**Teaching Language:**

English

**Teacher(s) in Charge:**

D.Sc. (Tech.) Juhamatti Korhonen

**Aims:**

Upon completion of the course the student will be able to program with VHDL hardware design language and design and implement digital systems by using programmable logic circuits.

**Contents:**

Circuit design of digital electronics with programmable logic circuits. Principles of digital circuit design, system level synthesis, hardware design languages.

**Teaching Methods:**

Lectures 14 h, exercises, 14 h, 3rd period. Lectures 14 h, exercises, 14 h, assignment, 4th period. Examination.
Total workload 156 h.

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, examination 25 %, assignment 1 25 %, assignment 2 50 %.

**Course Materials:**

To be announced in class.

**Prerequisites:**

Basics of digital design and digital electronics, basics of programming.

**Places for exchange-students? (Yes, number/No):**

Yes, 15

**Places for Open University Students?(Yes, number/No):**

Max. 15

### BL40A1740: Digital Electronics, 3 cr

**Validity:** 01.08.2017 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Jero Ahola, Tero Ahonen

**Year:**

M.Sc. (Tech.) 1

**Period:**

2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Antti Pinomaa, D.Sc. (Tech.), Post-doctoral researcher

**Aims:**

After the completion of course, the student is able to design, implement and simulate digital systems based on sequential logic. He/she is able to describe the functionality and implementation of basic sequential logic circuits, registries, memories, programmable logic circuits. In addition, the student is able to understand how digital systems are implemented with electronics and what physical limitations are involved.

**Contents:**

Sequential logic, components based on sequential logic, registries, memories, programmable logic circuits, design, simulation and implementation of digital systems, design of algorithmic state machines.

**Teaching Methods:**

Lectures 18 h, exercises 12 h, individual weekly assignments, independent study 48 h.
Total workload 78 h.

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, exam 100%. 70% of weekly assignments satisfactorily passed.

**Course Materials:**

Lecture material in Moodle.
Additionally, it is recommended to follow the book Floyd, Digital Fundamentals to the appropriate extent.

**Prerequisites:**

BL40A1730 Digitaalitekniikka (Digital technology)
Basics of digital technology (Boolean algebra, combinatorial logic systems)

**Places for exchange-students? (Yes, number/No):**

max 15

**Places for Open University Students?(Yes, number/No):**

max 15

### BL40A2700: System Engineering Project Work, 6 cr

**Validity:** 01.08.2013 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Olli Pyrhönen, Jero Ahola, Jan-Henri Montonen, Tuomo Lindh

**Year:**

M.Sc. (Tech.) 2

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Associate professor. D.Sc. (Tech.) Tuomo Lindh, professor, D.Sc. (Tech.) Olli Pyrhönen, professor, D. Sc. (Tech.) Jero Ahola

**Aims:**

Upon completion of the course the student is prepared to work in a R&D team as a system engineer. The student is able to manage the project scheduling and project roles, and share responibilities among group members. The student can produce a tecnical documentation.

**Contents:**

The students will analyse and design a selected electrical energy conversion system in the field of industrial electrical drives, renewable energy conversion or motion control system. The topics are linked to an on-going research project or industrial co-operation in the above-mentioned fields. The project work includes several partly alternative system engineering tasks, such as project planning, preliminary system design, dynamic modelling and simulation, component dimensioning, electrical dimensioning, control design, automation design, control software design and project documentation. The tasks are project dependent and will be defined in the project plan.
Introduction to a system engineering approach in technical projects. Project documentation, different tasks in project work, project planning and implementation, example projects, execution of system engineering tasks, project documentation and presentation. The main result of the project work is technical project documentation including an overall description and the results of agreed system engineering tasks.

**Teaching Methods:**

Introductory lecture, independent group working (3-5 students in one group), individual tasks within the group work, project group meetings with supervisors, writing project documentation, project presentation and demonstration. The project work topics will be defined in detail at the beginning of the course.
Total workload 156 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, Project work that includes management of the project, system design, problem solving, designs, documentation and presentation.
Also the project phases from setting the goals to the design, implementation and utilization are graded.

**Course Materials:**

Project related material.
Jürg Kuster, Eugen Huber, Robert Lippmann, Alphons Schmid, Emil Schneider, Urs Witschi,Roger Wüst. Project Management Handbook, ISBN 978-3-662-45373-5.

**Prerequisites:**

A majority of the M.Sc. (El. Eng.) studies should be completed before participation.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

This course has 1-5 places for open university students. More information on the web site for open university instructions.

## TuSOEntr: Entrepreneurship, minor, 20 - 35 cr

**Validity:** 01.08.2016 -

**Form of study:**

**Type:** Study module

**Unit:** LUT School of Business and Management

*Obligatory course 6 cr*

**CS34A0302: Entrepreneurship Theory, 6 cr**

**Validity:** 01.08.2016 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Business and Management
**Grading:** Study modules 0-5,P/F
**Teachers:** Timo Pihkala, Marita Rautiainen

**Note:**

Course is also a part of the Entrepreneurship minor subject.

**Year:**

M.Sc. (Tech.) 1

**Period:**

1

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, D.Sc. (Econ. & Bus. Adm.) Timo Pihkala
D.Sc. (Econ. & Bus. Adm.) Marita Rautiainen

**Aims:**

The aim ofthis course is to give an overview of different forms of entrepreneurship, itsimportance for economies and the people involved. Besides studying anddiscussing a selection of academic articles, students will be actively involvedin the entrepreneurial process through practical cases. After the course, students should be able to:

- Prove evidence of a comprehensive knowledge of the concepts and theories used in the course
- Prove evidence of (research and case-based) empirical knowledge regarding the different topics covered by the course
- Be able to link theoretical knowledge with empirical insights and apply it to practical cases, in particular:
    - Be able to analyze a business case and critically assess the quality of entrepreneurial strategies and tactics based on theoretical and practical insights
    - Be able to find and evaluate relevant literature and empirical evidence to support the analysis of specific topics covered by the course
    - Be able to critically assess the validity of statements based on empirical research

**Contents:**

Basic concepts of entrepreneurship, entrepreneurship theory, entrepreneurial person and the latest theoretical directions.

**Teaching Methods:**

Independent studies 148 h, lectures 8 h, total 156 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Doctoral School course where enrollment is in WebOodi (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

Yes

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, Moodle-exams (50%) and written assignment (50%).

**Course Materials:**

Bridge, S., O´Neill, K. and Cromie, S. (2003): Understanding, Enterprise, Entrepreneurship and Small Business. (2nd ed.) Palgrave-MacMillan Shane, Scott: A general theory of entrepreneurship. The individual-opportunity nexus. Edward Elgar. Lecture materials

**Limitation for students? (Yes, number, priorities/Leave empty):**

Yes, maximum 100. Priority is given to the student in Entrepreneurship masters program and students of entrepreneurship minor.

**Places for exchange-students? (Yes, number/No):**

15–

**Places for Open University Students?(Yes, number/No):**

15–

*Elective studies*

**CS30A1372: Creative Design and Problem Solving, 6 cr**

**Validity:** 01.08.2016 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Business and Management

**Grading:** Study modules 0-5,P/F

**Teachers:** Andrzej Kraslawski

**Year:**

M.Sc. (Tech.) 1

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, Ph.D. Andrzej Kraslawski

**Aims:**

Learning outcomes: After fulfilling all requirements of the course, the students will be able to: 1. Understand the principles of creative problem solving 2. Know the basic methods of creative design 3. Work in team during the design process 4. Apply methods of creative design to products, processes, services and business methods

**Contents:**

The major subjects of the course are: Major Steps in Problem Solving Types of Problems Types of Design Concept of Creativity Survey of Intuitive and Structured Methods of Creativity Enhancement Types of Brainstorming Check lists Morphological analysis Synectics Case-based Reasoning Graphical Methods Evaluation of Ideas

**Teaching Methods:**

The course is organised as a combination of regular lectures and interactive problem-solving sessions and project works. The in-class problem-solving sessions will be based on the team work realised by the

groups of 3-5 students. The 3-4 project works will be realised by the groups of 3-4 students during the out-of-class activities and it will be finished with the preparation of the project report. In-class teaching and problem-solving sessions 42 h, project works 88 h. Total workload 130 h.

Lectures, in class activity, period 1.
Project work, out-of - class activity, period 2.
Project work 88 hours

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Doctoral School course where enrollment is in WebOodi (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

Final grade 0-5. Evaluation: Generated solutions of the in class problems 40 %, project reports 30 %, written exam 30%. Obligatory presence during 80% of in-class activities.

**Course Materials:**

Course slides.

Tony Proctor
Creative problem solving for managers
Routledge, 3rd edition, 2009

H. Scott Fogler and Steven E. LeBlanc
Strategies for Creative Problem Solving
Prentice Hall, 3rd edition , 2013

David Silverstein, Philip Samuel, Neil DeCarlo
The Innovator's Toolkit: 50+ Techniques for Predictable and Sustainable Organic Growth
Wiley, 2009

Alexander Osterwalder and Yves Pigneur
Business Model Generation
Osterwalder and Pigneur, 2010

**Prerequisites:**

Basic courses of management. Basic knowledge of engineering disciplines (e.g. process or mechanical engineering).

**Limitation for students? (Yes, number, priorities/Leave empty):**

Yes, 80

**Places for exchange-students? (Yes, number/No):**

15–

**Places for Open University Students?(Yes, number/No):**

max 5

**CS30A1691: Social Sustainability, 6 cr**

**Validity:** 01.08.2016 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Business and Management

**Grading:** Study modules 0-5,P/F

**Teachers:** Suvi Konsti-Laakso, Suvi-Jonna Martikainen, Helinä Melkas, Rakhshanda Khan, Satu Pekkarinen

**Year:**

B.Sc. (Tech.) 3

**Period:**

4

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, D.Sc. (Tech.) Helinä Melkas
Rakhshanda Khan, PhD, Senior Researcher
Satu Pekkarinen, PhD, Senior Researcher
Suvi Konsti-Laakso, M.Sc., Researcher
Suvi-Jonna Martikainen, MA, Researcher

**Aims:**

After completion of the course, students will be able to
- explain and analyze the significance and meaning of social sustainability in development of business, organization and product and service processes
- discuss both theoretical and practice-based viewpoints as well as the kinds of tools and methods that enable social sustainability to become part of business, management and product and service development
- determine and compare appropriate situations for applying these methods
- differentiate between elements for critical thinking concerning social sustainability.

**Contents:**

Core content: social sustainability at different levels (global, societal and organizational), social innovation, frugal innovation, social enterprise, end-user involvement, employee involvement.
Supplementary content: practical cases, methods and Living Lab activities.

**Teaching Methods:**

Lectures (intensive teaching) and small group assignments during the lectures 5 h, case exercise to be given during the lectures 60 h, independent and/or group studies 60 h, presentation of case exercises in a closing seminar 10 h, personal learning diary 21 h = total 156 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0 - 5. Case exercise 70%, learning diary 30%.

**Course Materials:**

The study materials consist of course slides and selected articles (will be announced later).

**Prerequisites:**

None.

**Places for exchange-students? (Yes, number/No):**

max 15

**Places for Open University Students?(Yes, number/No):**

max 5

### CS34A0352: Leading business growth, 6 cr

**Validity:** 01.01.2018 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Business and Management
**Grading:** Study modules 0-5,P/F
**Teachers:** Mikko Pynnönen

**Year:**

M.Sc. (Tech.) 1

**Period:**

1

**Teaching Language:**

English

**Teacher(s) in Charge:**

Mikko Pynnönen, D.Sc. (econ.), Professor

**Aims:**

The students become familiar with the basic concepts of entrepreneurial growth, growth strategies and the latest theoretical directions within entrepreneurship research. After the course, the students are able recognize different forms of growth, growth potential and routes for business development.

**Contents:**

Models, theories and approaches on entrepreneurial growth, growth strategy and SME development.

**Teaching Methods:**

Lectures 18h, 1st period.  Prior reading and assignments 106 h, essay writing, 30 h. In total 154 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, Group assignments 50%, essay 50%.

**Course Materials:**

Cases and articles delivered during the course. Lecture materials.

**Places for exchange-students? (Yes, number/No):**

max 5

**Places for Open University Students?(Yes, number/No):**

max 5

### CS34A0401: Strategic Entrepreneurship in an Age of Uncertainty, 6 cr

**Validity:** 01.08.2016 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Business and Management

**Grading:** Study modules 0-5,P/F

**Teachers:** Justyna Dabrowska, Marko Torkkeli, Ekaterina Albats

**Year:**

M.Sc. (Tech.) 1

**Period:**

3

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, D.Sc. (Tech.) Marko Torkkeli

**Aims:**

Managing in a knowledge-based economy, Managing by Core Competences, Knowledge intensive firms, Uncertainty. Are they the latest buzz words or another passing managerial fad? Old wine in new bottles? Or perhaps, just perhaps, fundamental means of survival and success for modern day corporations? Given the amount of effort that has been devoted to the topic by both academics and practitioners, it appears worth taking a deep and dispassionate look at the role of entrepreneurial thinking in sustained competitive advantage. The goal is to learn as you go and effectively convert assumptions to knowledge at a low cost.
By the end of the course, students will be able to identify business opportunities and analyze them using different tools of uncertainty management. Students will be able to understand the main components of different pitches and be able to design and present a pitch.

**Contents:**

During the course students learn to develop and test a business idea following the feasibility analysis, discovery driven planning steps as well as using the uncertainty management tools of Attribute Mapping, Supply Chain Analysis, Differentiation, Quizzing and Market-Busters. The course does not teach business plan writing but rather focuses on opportunity recognition and feasibility assessment. Moreover, it adds the elements of lean startup as well as social entrepreneurship as possible avenues in dealing with entrepreneurial challenges.
Entrepreneurial thinking, uncertainty management, strategic entrepreneurship, discovery-driven planning.

**Teaching Methods:**

Lectures 20 h, Independent study 73 h, seminar work writing 63 h, Total 156 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0 - 5. Based on assignment and in-class work, participation in the lectures required (possibility to substitute absence with literary work).

**Course Materials:**

Lectures and additional reading provided in the class. Book: McGrath Rita and MacMillan Ian, (2000). The Entrepreneurial Mindset. Harvard Business School Press.; McGrath Rita and MacMillan Ian, (2005). MarketBusters: 40 strategic moves that drive exceptional business growth. Harvard Business Press.

**Limitation for students? (Yes, number, priorities/Leave empty):**

60, priority for GMIT students and others to whom this course is part of the major.

**Places for exchange-students? (Yes, number/No):**

Yes, max 15

**Places for Open University Students?(Yes, number/No):**

This course has 1-5 places for open university students. More information on the web site for open university instructions.

### CS34A0551: Business Idea Development, 6 cr

**Validity:** 01.08.2016 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Business and Management
**Grading:** Study modules 0-5,P/F
**Teachers:** Suvi Konsti-Laakso, Timo Pihkala

**Year:**

M.Sc. (Tech.) 1

**Period:**

2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Timo Pihkala, D.Sc. (Econ. & Bus. Adm.), Professor
Suvi Konsti-Laakso, M.Sc.(Tech.), Project researcher

**Aims:**

Student can explain and analyze key theoreticalapproaches associated to business idea development. The student learns toidentify, develop and assess future-oriented business opportunities and ideas.The student can use different systematical tools and techniques related tobusiness idea development.

**Contents:**

Fuzzy-front end of entrepreneurial process, opportunityrecognition, innovation, sources of business ideas, creativity and systematicgeneration of ideas

Supplementary content: innovation and creativity
Specific content: customer/user involvement

**Teaching Methods:**

12 h of lectures/seminars, learning diary and assignments 80 h. Written group assignment 64 h. In total 156 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

Grades 0-5, Learning diary (60%) and group work and presentation (40)%.

**Course Materials:**

Study materials will be available in Moodle.

**Places for exchange-students? (Yes, number/No):**

15–

**Places for Open University Students?(Yes, number/No):**

15–

### CS34A0712: Business Governance and Entrepreneurial Renewal, 6 cr

**Validity:** 01.01.2018 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Business and Management

**Grading:** Study modules 0-5,P/F

**Teachers:** Tuuli Ikäheimonen, Timo Pihkala

**Year:**

M.Sc. (Tech.) 1

**Period:**

2

**Teaching Language:**

English

**Teacher(s) in Charge:**

D.Sc. (Econ. & Bus. Adm.) Tuuli Ikäheimonen
Professor, D.Sc. (Econ. & Bus. Adm.) Timo Pihkala

**Aims:**

After completing the course the student:
- Knows the key theories in the field of governance, and understands thetheoretical starting points for governance research
- Understands the overall governance system and its various actors, and therole of the actor in the governance system.
- Understands the relationships between governance actors, key stakeholders andbusiness environment
- Is able to analyze the company's characteristics, business and environmentand, basing on this, to provide suggestions for governance solutions that suitthe company's situation.
- Is able to identify the role and possibilities of the board of directors and itsindividual members in corporate renewal and business development.
- Is able to analyze the company boards and provide suggestions for their development

**Contents:**

Different types of businesses (e.g. SMEs, family businesses,start-ups). Owners and stakeholders influence on governance. The concept andcontent of ownership strategy. Governance mechanisms. Advisory boards, familycouncils, the board of directors, top management teams. The structure,processes and roles of the board of directors. Governance research, theoreticalbase and research objectives. Development of governance. The role of the boardand individual board members in company renewal and business development.

**Teaching Methods:**

Lectures 20 h, 2nd period. Independent study 71 h, Course assignments 65 h. Total workload 156 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

Yes

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, course assignments 100%.

**Course Materials:**

Will be announced later.

**Places for exchange-students? (Yes, number/No):**

15–

**Places for Open University Students?(Yes, number/No):**

max 10

### CS34A0721: Entrepreneurship, ownership and family firms, 6 cr

**Validity:** 01.08.2016 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Business and Management
**Grading:** Study modules 0-5,P/F
**Teachers:** Marita Rautiainen, Timo Pihkala

**Year:**

M.Sc. (Tech.) 1

**Period:**

3

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, D.Sc. (Econ. & Bus. Adm.) Timo Pihkala
D.Sc. (Econ. & Bus. Adm.) Marita Rautiainen

**Aims:**

The courseintroduces the student with the phenomenon of entrepreneurship, ownership, andfamily firm. The course aims to enhance students' understanding of thecharacteristics, contributions, and issues surrounding family business. Throughcase studies, student research and guest speakers, we consider questions ofownership, succession, conflict resolution, sibling rivalry, compensation,attracting and retaining both family and nonfamily talent, estate planning, andfinancing the family owned enterprise. After the course, students should beable to define and understand the conceptual special characteristics and thecentral theories of these phenomena. In addition, students learn to applydifferent theories in the analysis of practical cases as well as aboutways to manage the transitional processes such as family business succession. Itcombines rigorous learning with practical group works. The course willappeal to those who are interested in starting up their own business, as wellas those interacting with small firms and family businesses as advisors,managers and policy-makers.

**Contents:**

Course explores the unique challenges and opportunities involved in managing a family firm. The course will address a wide variety of topics, including: the strengths and weaknesses of a family firm, the dynamics of family interactions, family business culture, conflict resolution in a family firm, transferring

ownership of a family firm, planning for a family firm's growth and continuity, effective leadership and communication, and planning for succession.

**Teaching Methods:**

Lectures 20 h 3rd period. Prior reading and assignments 106 h. Preparation for lectures 30 h. In total 156 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

Yes

**Examination in Exam (Yes/No):**

No

**Assessment:**

Individual exercise 50 %, group exercise 30 % moodle exam 20 %

**Course Materials:**

1.Ernesto J. Poza (2010). Family Business, South-Western, Cengage Learning.
2.Materials indicated during lectures
3.Cases and articles delivered during the course.

**Limitation for students? (Yes, number, priorities/Leave empty):**

Yes, maximum 80. Priority is given to the student in Entrepreneurship masters program and students of entrepreneurship minor.

**Places for exchange-students? (Yes, number/No):**

15–

**Places for Open University Students?(Yes, number/No):**

15–

### CS34A0733: New Venture Creation, 6 cr

**Validity:** 01.01.2018 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Business and Management

**Grading:** Study modules 0-5,P/F

**Teachers:** Henri Hakala, Kirsi Snellman

**Note:**

Schedule: intensive lecturing at the beginning of the period, independent group work, business planin pitching competition at the end of the period

**Year:**

M.Sc. (Tech.) 1

**Period:**

3

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, D.Sc. Henri Hakala
Post-doctoral researcher, D.Sc, Kirsi Snellman

**Aims:**

The course targets on the entrepreneurial phenomenon and especially on start-up analysis. After the course the student is familiar with entrepreneurship theory that integrates creativity, resource-based characteristics and finance. In addition, the student will understand the start-up process, and is able to prepare a business plan.

**Contents:**

Entrepreneurship process, start-up theory, start-up strategies, financial analysis of the business concept, business plan and evaluation criteria.

**Teaching Methods:**

Lectures 8 h. Pitching competition 8 h, Online study and independent reading 76 h. Written assignment 70 h. In total 162 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

Grades 0-5, evaluation 0-100 points. Assignments 100%. (pitching competition 30%, written business plan 70%)

**Course Materials:**

Kubr, T., Marchesi, H., Ilar, D., Kienhuis, H. (2013). Starting Up: achieving success with professional business planning. McKinsey.
Lecture/Moodle material

**Limitation for students? (Yes, number, priorities/Leave empty):**

Yes, maximum 80. Priority is given to the student in Entrepreneurship masters program and students of entrepreneurship minor.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

No

## YmDSaResp: Environmental Responsibility, 20 - 30 cr

**Validity:** 01.08.2016 -

**Form of study:**

**Type:** Study module

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Aims:**

After completing this minor subject the student will be able to:
- understand the importance of sustainability to business
- understand the roles buildings and their technologies as part of a sustainable community
- recognize the most applicable waste treatment methods for waste fractions
- recognize possibilities for the utilization of energy content of waste

*Obligatory Studies 23 ECTS cr*

### BH60A0252: Solid Waste Management Technology, 7 cr

**Validity:** 01.08.2016 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Mika Luoranen, Jouni Havukainen, Mika Horttanainen

**Year:**

M.Sc. (Tech.) 1

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, D.Sc. (Tech.) Mika Horttanainen

**Aims:**

Upon completion of the course the student is expected to be able to
1. explain the most important generation mechanisms, properties, and collection and treatment systems of solid waste,
2. explain the operation of essential process technology and equipment,
3. compare and give grounded proposals for treatment methods and processes applicable to different situations,
4. calculate process parameters related to composting, digestion and energy utilization,
5. apply waste management legislation,
6. apply what he/she has learned to the environmental treatment and utilization of waste, and
7. describe the operation of regional waste management.

**Contents:**

Generation of solid waste and waste management in different parts of the world, properties of waste, legislation concerning waste management, source separation, collection and transport, pretreatment, composting, anaerobic digestion, waste-to-energy, landfilling, regional waste management, treatment of polluted soil.

**Teaching Methods:**

1st period: 14 h of lectures, 10 h of tutorials. 2nd period: 12 h of lectures, 8 h of tutorials. Assignment with literature and calculation part, presentation, individual work approx. 82 h. Field trip approx. 12 h. Lecture assignments approx. 10 h. Examination and preparation for it approx. 30 h. Total workload 182 h.

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0 - 5. Examination 50 %, assignment 40 %, lecture assignments 10 %.

**Course Materials:**

Tchobanoglous, Theisen, Vigil: Integrated Solid Waste Management, 1993. Handouts provided by the lecturer, course environment on Moodle.

**Prerequisites:**

BH60A0001 Ympäristötekniikan perusteet, BH60A0901 Ympäristömittaukset or equivalent knowledge

**Places for exchange-students? (Yes, number/No):**

max 15

**Places for Open University Students?(Yes, number/No):**

max 10

### BH60A2401: Energy Recovery from Solid Waste, 4 cr

**Validity:** 01.08.2010 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Mika Luoranen, Mika Horttanainen

**Year:**

M.Sc. (Tech.) 2

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, D.Sc. (Tech.) Mika Horttanainen

**Aims:**

Upon completion of the course the student is expected to be able to
1. describe the properties of waste as fuel,
2. explain the most common waste-to-energy technologies and their suitability for different energy recovery applications and materials,
3. determine the waste-to-energy recovery potential of a region,
4. describe the most important flue gas emissions and their reduction technologies characteristic for the combustion of waste, and
5. analyse the role of energy recovery in municipal waste management.

**Contents:**

Waste-to-energy in Finland and other countries, properties of waste as a fuel, waste handling before thermal conversion, preparation of recycled fuel, mass combustion of waste, combustion of recycled fuel, gasification of waste, energy recovery in combustion of waste, emission reduction during combustion, flue gas treatment, utilisation and treatment of ash, energy recovery in anaerobic digestion of waste, landfill gas utilisation in energy production.

**Teaching Methods:**

1st period: 14 h of lectures, 14 h of exercises.
2nd period: 4 h of lectures, assignment info (2 h). Group assignment including calculations, written group report (approx. 44 h). Excursion (approx. 6 h). Written examination and preparation for it, approx. 20 h. Total workload 106 h.

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

Yes

**Assessment:**

0 - 5. Examination 50 %, practical assignment 50 %.

**Course Materials:**

Course book (to the appropriate extent): Niessen, W., 2002. Combustion and incineration processes. Marcel Dekker, Inc., New York. SBN: 0-8247-0629-3. Moodle.

**Prerequisites:**

Basic knowledge on thermodynamics, chemistry and power plant technology.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

max 5

### BH60A2701: Energy Efficient Environment, 6 cr

**Validity:** 01.08.2016 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Risto Soukka, Mika Luoranen

**Year:**

M.Sc. (Tech.) 2

**Period:**

3-4

**Teaching Language:**

English

**Teacher(s) in Charge:**

Mika Luoranen, D.Sc. (Tech.), Associate professor

**Aims:**

Upon completion of the course the student is expected to be able to:
1. assess the energy related factors that affect areal planning,
2. compare the factors that affect the sustainability of energy solutions for individual buildings and areas, and
3. plan and execute a procedure for comparing relevant energy aspects of competing energy supply alternatives for a housing area.

**Contents:**

The lectures deal with the following topic areas: regional energy planning; legal and economic control factors; low energy buildings, regional energy supply and environmental performance criteria. Students will complete an assignment in which they assess energy supply alternatives for a given region, including life cycle perspective.

**Teaching Methods:**

3rd period: 7 x 2 h of lectures
3rd - 4th period: Independent work: individual assignment (approx. 102 h).
Examination and preparation for it (approx. 40 h). Total workload 156 h.

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0 - 5. Examination 50 %, assignment 50 %.

**Course Materials:**

Lecture material, Moodle.

**Prerequisites:**

Recommended: BH60A2101 Advanced Course in Life Cycle Assessment attended.

**Places for exchange-students? (Yes, number/No):**

max 5

**Places for Open University Students?(Yes, number/No):**

max 5

### BH60A5700: Business and Sustainability, 6 cr

**Validity:** 01.01.2018 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F

**Note:**

Replaces the course BH60A3001 Corporate Responsibility and Management 2.

**Year:**

M.Sc. (Tech.) 1

**Period:**

3-4

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, D.Sc. (Econ. & Bus. Adm.), M.Sc. (Tech.) Lassi Linnanen
Associate Professor, D.Sc. (Agr. & For.) Mirja Mikkilä

**Aims:**

Upon the completion of the course the student is expected to be able to:
1. analyze decision making situations related to sustainable business,
2. propose solutions to challenging business situation within sustainable business,
3. understand various sustainable business and enterprise models,
4. evaluate critically responsible corporate communication,
5. discuss and argument on various perspectives of sustainable business based on the learned issues and on-going societal debate.
6. carry out self- and peer evaluations

**Contents:**

Familiarization with the sustainable business models and the strategic responsibility framework of a firm. Reorganization of dimensions of responsible business. Deepening the application skills of mechanisms and tools of sustainable management. Analysisof business and financial consequences of responsibility governance. Familiarization of basics of business ethics. Communication and reporting ofgoals and

implementation of corporate responsibility to stakeholders. Learning of corporate responsibility reporting guidelines.

**Teaching Methods:**

Lectures 6 h, 3 period. Written report on Corporate Responsibility communication and preparation of seminar presentation, groupwork approximately 30 h, written report 3 period.
Seminar presentation 4. period. Case-assignments, group work, approximately 120 h, 3-4 period. The student mustparticipate in the case-assignments.
Total workload 156 h, of which independent work approximately 118 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Doctoral School course where enrollment is in WebOodi (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

Evaluation 0 - 5. Written report 30 %, case-assignments 70 %.

**Course Materials:**

Caset: Hamschmidt, Jost (toim.): Case studies in sustainability management and strategy: the Oikos collection, 2007,
Pirson, Michael (toim.): Case studies in social entrepreneurship: the Oikos collection, 2015,
GRI yhteiskuntavastuun raportointiohjeisto, versiot 3.1 ja 4. Further course material will beannounced during the lectures,
Course material in Moodle

**Prerequisites:**

Sustainability transition and sustainable business (Kestävyysmuutos ja johtaminen) or Introduction to Sustainable Business
passed or equivalent knowledge studied earlier.

**Places for exchange-students? (Yes, number/No):**

Max 5

**Places for Open University Students?(Yes, number/No):**

Max 5

## KaSOIbm: International Business and Management, 21 - 35 cr

**Validity:** 01.08.2016 -

**Form of study:**

**Type:** Study module

**Unit:** LUT School of Business and Management

**Grading:** Study modules 0-5,P/F

**Note:**
This minor is not allowed for the students of Business Administration.
The number of students attending to the courses in the minor can be limited. In these cases the priority is given to the students who have these courses in their compulsory studies.

**Aims:**

Minor in International Business and Management aims to provide basic knowledge on marketing and sales management as well as their idiosyncracies that arise from doing international business. After completion of this minor, the students are able to analyze, plan and develop the processes of marketing and sales in international business context. In addition, they understand the cultural issues that arise from international operating environment. The students possess good skills in communication, cooperation and project management.

*Elective courses 21-24 cr*

### A370A0401: Case-Course of Business, 6 cr

**Validity:** 01.08.2012 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Business and Management
**Grading:** Study modules 0-5,P/F
**Teachers:** Jukka-Pekka Bergman

**Year:**

B.Sc. (Econ. & Bus. Adm.) 3

**Period:**

1-2, 3-4

**Teaching Language:**

English

**Teacher(s) in Charge:**

Post-Doctoral Researcher, D.Sc. (Tech.), Dos. Jukka-Pekka Bergman

**Aims:**

The aim of the course is to familiarize students with the case-writing through the self-oriented independent team work by making an exersice of a *business analysis of a real case firm*. The students are able to evaluate and describe firm's business practices, markets, and explain their development using the frameworks she or he has learned at previous courses. The student is able to construct a well-written description of a case-firm and its business environment as well as provide concluding suggestions for the development targets for the firm using different empirical materials collected during the exercise. In addition, students train to organize and study the group work by themselves being collectively/as a group responsible for the case process and results.

**Contents:**

Strategy analysis. Case study methodology. Case-writing.

**Teaching Methods:**

Lectures 4 h, selection of case-company and collection of data 40 h, reading of the literature needed in the analysis and description of the case 40 h, case-writing in English (international groups) or Finnish 76 h and possible final seminar (4 hours). Total workload for student 160 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

Grade 0-5, evaluation 0–100 p. Literary group assignment 100%.

**Course Materials:**

Lecture slides.

**Prerequisites:**

B. Sc. (Econ. & Bus. Adm.) 2 studies

**Places for exchange-students? (Yes, number/No):**

15–

**Places for Open University Students?(Yes, number/No):**

max 10

**Description and DL of the company assignment:**

Exercise is a real-life business case that can/recommended to be a project for a company.

**A380A0000: Cross-Cultural Issues in International Business, 6 cr**

**Validity:** 01.08.2011 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Business and Management
**Grading:** Study modules 0-5,P/F
**Teachers:** Igor Laine

**Year:**

B.Sc. (Econ. & Bus. Adm.) 2

**Period:**

3

**LUT Winter School time:**

Yes

**Teaching Language:**

English

**Teacher(s) in Charge:**

Post-doctoral researcher, D.Sc. (Econ. and Bus. Adm.) Igor Laine

**Aims:**

The goal of the course is to give an understanding of how the cultural environment affects management in international business, and advance students' global mindset by giving conceptual tools to increase their intercultural competence. After completing the course the students will be able to:
1. define and categorize culture
2. explain cultural orientations towards time, space and context
3. analyze and compare national cultures according to Hofstede's, Trompenaars' and GLOBE cultural dimensions
4. reflect upon the relationship between culture, organizations and management - evaluate the effects of the cultural environment on international marketing strategies
5. examine the sources of cultural conflicts in international organizations
6. identify the role of cultural factors in managing and leading international teams
7. apply studied theories and ideas to business situation

The general aim of the course is to improve following personal skills and abilities of the students:
- recognizing cultural differences
- interacting effectively with people from other cultures
- working in groups and international teams

**Contents:**

Concept and levels of culture, dimensions of culture in business (Hall, Hofstede, Trompenaars and GLOBE); The effect of culture on leadership and management in international business; The limits of

globalization from the cultural perspective; Cross-cultural issues in virtual teams; Standardization and adaptation in international marketing; Country cases of cultural differences (term paper reports)

**Teaching Methods:**

15 hours of lectures, case study workshop (2 hours) and term paper presentation seminar (4 hours). Preparation for lectures 12 h. Writing of term paper, preparation for case study and term paper presentations, 63 h. Written exam and preparation for exam 65 h. Total workload for student 160 h.

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

Yes

**Assessment:**

Grade 0-5, evaluation 0-100 points, written exam 60 %, term paper 25 %, peer group evaluation report 5 %; case assignment 10 %, all assignments must be passed to obtain a final grade.

**Course Materials:**

1.Browaeys & Price: Understanding Cross-Cultural Management (3rd ed), Pearson, 2015
2.Lecture slides
3.Additional material distributed in class and via Moodle

**Prerequisites:**

Basic course in management or marketing

**Places for exchange-students? (Yes, number/No):**

15–

**Places for Open University Students?(Yes, number/No):**

max 10

### A380A0131: Business Relationships in International Value Networks, 6 cr

**Validity:** 01.01.2018 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Business and Management

**Grading:** Study modules 0-5,P/F

**Teachers:** Terhi Tuominen, Anni-Kaisa Kähkönen

**Note:**

If student has taken the course of A380A0130 Kansainväliset liikesuhteet arvoverkostoissa, the student is not able to participate to this course.

**Year:**

B.Sc. (Econ. & Bus. Adm.) 3

**Period:**

1

**Teaching Language:**

English

**Teacher(s) in Charge:**

Associate Professor, D.Sc. (Econ. & Bus. Adm.) Anni-Kaisa Kähkönen
Post-Doctoral Researcher, D.Sc. (Econ. & Bus. Adm.) Terhi Tuominen

**Aims:**

The aim of the course is to familiarize students with different business relationships in value networks, with the management of relationships and networks, and the characteristics of international business relationships and collaborative networks.
Upon completion the course students are able to
- understand the main concepts and theoretical backgrounds of collaboration and networks
- analyze the benefits and challenges of relationships and networks
- recognize and understand the characteristics of value networks
- define supplier and customer relationships
- participate to the development of relationships.

**Contents:**

The concepts and theories of collaboration and networking, characteristics of value networks, the benefits and challenges of collaboration, managing of collaboration and networks, vertical and horizontal collaboration, the management of supplier relationships and customer relationships.

**Teaching Methods:**

Online course, student driven content creation anddiscussion. Reading assignments and writing of essays 40 h. Case assignmentincluding written reports, 60 h, in small groups. Independent Moodle exam and preparation for exam 60 h, 1stperiod. Total workload for student 160 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

Yes

**Examination in Exam (Yes/No):**

No

**Assessment:**

Grade 0-5, evaluation 0-100 points. Exam 40 %, case assignment 40 %, essays 20 %, all assignments must be passed to obtain final grade.

**Course Materials:**

1. Selection of journal articles, 2. Assigned readings

**Prerequisites:**

B.Sc. (Econ. & Bus. Adm.) General studies

**Places for exchange-students? (Yes, number/No):**

15–

**Places for Open University Students?(Yes, number/No):**

15–

### A380A0201: Sales and Marketing Communication, 6 cr

**Validity:** 01.01.2018 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Business and Management

**Grading:** Study modules 0-5,P/F

**Teachers:** Anssi Tarkiainen, Tommi Rissanen

**Note:**

Replaces the course A380A0200 Promotion and Sales Management 6 cr

**Year:**

B.Sc. (Econ. & Bus. Adm.) 3

**Period:**

2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Associate Professor, D.Sc. (Econ. & Bus. Adm.) Anssi Tarkiainen
Doctoral Student, M.Sc. (Econ. & Bus. Adm.) Tommi Rissanen

**Aims:**

After completing the course the student will understand changes in the field of commerce, including buying behavior, marketing communication (MC) and sales management (SM). Student is able to create and design marketing and sales funnel that applies new, more productive technologies. This course will pay special emphasis on understanding the linkages between marketing communication and sales, and the challenges in their integrated management.
The learning outcomes of the course are the following:
- to understand the evolution of buying behavior, marketing and sales in the era of digital technologies
- to understand the role of MC and SM in marketing strategy
- to assess the usability of different forms of communication with regard to buyer behavior
- to be able to design, implement and manage marketing communication and sales as part of the marketing process
- to assess the challenges of integrating MC and sales strategies, and combining traditional tools with new technologies
- to evaluate the effectiveness of MC and sales in the changing business environment.

**Contents:**

Core contents:
- The evolution of buying behavior, marketing and sales in the era of digital technologies.
- The role of marketing communication (MC) and sales in marketing strategy.
- The role of buyer behavior and its effects on the nature of communication (mass vs interactive /personal).
- MC and sales process, message and media strategy.
- Strategic planning process of MC and sales; challenges of integrating MC and sales management strategies.
Additional knowledge:
- Sustainability in MC context.
Special knowledge:
- Digitalization of MC and sales.

**Teaching Methods:**

Combined lectures and exercises 28 h 2. period. Preparation for exercises 63 h (including written work) and preparation for the exam 71h. Written exam.
Total workload for student 160 h.

**Examination in Exam (Yes/No):**

Yes

**Assessment:**

Final grade 0-5, evaluation 0-100 points.Exercises 40 points, written exam 60 points.

**Course Materials:**

Lectures and selected articles.

**Prerequisites:**

A130A0250 Kansainvälisen markkinoinnin perusteet (or basic course in marketing).

**Places for exchange-students? (Yes, number/No):**

Yes, 15-

**Places for Open University Students?(Yes, number/No):**

Max 5

**A380A6050: Introduction to International Business and Planning, 3 cr**

**Validity:** 01.08.2011 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Business and Management

**Grading:** Study modules 0-5,P/F

**Teachers:** Seyedsina Mortazavibabaheidari, Toivo Äijö

**Year:**

B.Sc. (Econ. & Bus. Adm.) 3

**Period:**

1 (intensive)

**Teaching Language:**

English

**Teacher(s) in Charge:**

D.Sc. (Econ.) Toivo S. Äijö, Top Trainers Group
Professor, D.Sc. (Econ. & Bus. Adm.) Sami Saarenketo
Junior Researcher Sina Mortazavi

**Aims:**

To familiarize the students with the fundamentals of international business in general and strategic planning for international business in particular. To provide the students with the analytical skills required for critical evaluation of actual international business strategies.

**Contents:**

- The changes in the international Business environment and their effect on strategic planning.
- Theories of international trade and business.
- The institutions of international trade and business.
- The essence of competitive strategy.
- Levels of strategic planning.
- International expansion strategy.
- Supporting research.
- International marketing strategy: entry modes, targeting, product, service, pricing, promotion, sales and CRM.
- International functional strategies.
- Case studies.

**Teaching Methods:**

Intensive course during 1. period. 25 hours of lectures, interactive analyses, case exercises and assignments, carried out by the student, 55 hours, total course 80 h. Written examination.

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

Graded 0-5 on the basis of case studies and class participation 20 % and written examination 80 %, evaluation 0 – 100 points.
50 % class attendance and participation required.

**Course Materials:**

The study material will be distributed at the beginning of the lectures.

**Prerequisites:**

Basic course in marketing

**Places for exchange-students? (Yes, number/No):**

max 5

**Places for Open University Students?(Yes, number/No):**

max 10

### CS10A0262: International Business Essentials, 6 cr

**Validity:** 01.08.2017 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Business and Management

**Grading:** Study modules 0-5,P/F

**Teachers:** Juha Väätänen, Igor Laine, Asta Salmi

**Note:**

This course is available only to students of candidate programs of LUT School of Business and Management.
Interchangeable with CS10A0261 Managing International Business.

**Year:**

B.Sc. (Econ. & Bus. Adm.)or B.Sc. (Tech.) 2, 3

**Period:**

2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Post-doctoral researcher, D.Sc. (Econ. and Bus. Adm.) Igor Laine
Professor, D.Sc. (Econ. and Bus. Adm.) Asta Salmi
Professor, D.Sc. (Tech.) Juha Väätänen

**Aims:**

After successful completion of the course, students should be able to: 1. describe the key concepts in international business, 2. explain how international business differs from domestic business, 3. identify major participants in international business, 4. describe, discuss applicability and apply various internationalization theories, 5. describe strategy in international business, 6. describe various principles of market selection, 7. examine advantages and disadvantages of different entry modes, 8. discuss major features of global marketing program, 9. recognize the characteristics of international business relationships.

**Contents:**

International business theories. International competitiveness. Regional economic integration. International business strategy. Market selection and entry modes in international business. Global marketing. International business relationships and networking.

**Teaching Methods:**

15 h of lectures, 14 h preparation for lectures, 20 h assignments, 40 h written report, 3 h peer group evaluation, 14 h course literature and self-study, 50 h exam preparation. Total 156 h.

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0 - 5. Exam 40 %, written report 35 %, peer group evaluation 5%, home-work assignments 20%. Each of the components has to be passed acceptably.

**Course Materials:**

Cavusgil S.T., Knight G., Reisenberger J., 2017, International Business: The New Realities (4th edition), Harlow, UK: Pearson Education Ltd. Additional materials will be announced on lectures

**Limitation for students? (Yes, number, priorities/Leave empty):**

Yes, 75

**Places for exchange-students? (Yes, number/No):**

15–

**Places for Open University Students?(Yes, number/No):**

15–

## EnDMES: Modelling of Energy Systems, 21 cr

**Validity:** 01.08.2010 -

**Form of study:**

**Type:** Study module

**Unit:** LUT School of Energy Systems

**Aims:**
After the completion of the minor in Modelling of Energy Systems, the student:
• can use mathematical and physical models to model various processes and equipment, especially in energy technology context
• is able to use modelling tools and methods in design of various processes and equipment, especially in energy technology context
• understands the applicability of different modelling tools and their limitations.

*Selectable courses, choose a min. of 20 ECTS*

### BH70A0101: Advanced Modelling Tools for Transport Phenomena, 5 cr

**Validity:** 01.08.2009 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Payman Jalali, Timo Hyppänen

**Year:**

M.Sc. (Tech.) 1-2

**Period:**

3-4

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, D.Sc. (Tech.) Timo Hyppänen, Docent, D.Sc. (Tech.) Payman Jalali

**Aims:**

Transport phenomena are dealing with the heat, mass and momentum transfer in engineering and science. In this course, advanced modeling tools and methods are introduced for students of energy technology and other departments with related background in heat transfer and fluid dynamics. Students will learn how the related computer packages such as FLUENT, COMSOL Multiphysics and MATLAB can be used to solve and analyze heat transfer and fluid flow problems using computational fluid dynamics (CFD). This course provides a mathematical basis for problem formulation, and coding /solving using the above-mentioned computational packages. Students will learn how to solve simple transport problems using their own codes in MATLAB. Then more complex problems will be taught to solve using COMSOL and FLUENT packages. Upon completion of this course, they will be able to start working on various topics in heat and fluid flow engineering for advanced designs or analysis.

**Contents:**

Introduction to 'transport phenomena' and related problems, feeding problems into CFD algorithms and methods (discretization of equations and domains, transforming differential equations into algebraic equations etc.), diffusion and convection equations solved by finite
difference and finite volume methods, complexities due to property variation, geometry and boundary conditions, application of computational packages (such as MATLAB, FLUENT, COMSOL Multiphysics etc.) in solving transport phenomena problems.

**Teaching Methods:**

3rd period: 12 h of lectures, 12 h of exercises. 4th period: 12 h of lectures, 12 h of exercises. 3 - 6 homeworks and 2 projects.
Total workload 130 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

Yes

**Assessment:**

0 - 5. Examination 40 %, homeworks and projects 60 %.

**Course Materials:**

J.D. Anderson: Computational Fluid Dynamics, McGraw-Hill, Inc. 1995.
D.A. Anderson, J.C. Tannehill, R.H. Pletcher: Computational Fluid Mechanics and HeatTransfer, McGraw-Hill, Inc. 1984.
J.H. Ferziger, M. Peric: Computational Methods for Fluid Dynamics, Springer-Verlag 1996.
C. Hirsch: Numerical Computation of Internal and External Flows, Volume 1: Fundamentals of Numerical Discretization, John Wiley & Sons, 1988.
MATLAB user manual. FLUENT user manual. COMSOL Multiphysics manual. Moodle.

**Prerequisites:**

Basic knowledge on programming using MATLAB or any other language. Basic Fluid Mechanics and Heat Transfer courses passed.

**Places for exchange-students? (Yes, number/No):**

max 10

**Places for Open University Students?(Yes, number/No):**

max 5

**BH70A0200: Advanced Topics in Modelling of Energy Systems, 6 cr**

**Validity:** 01.08.2010 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Timo Hyppänen, Teemu Turunen-Saaresti, Juhani Vihavainen, Esa Vakkilainen, Tero Tynjälä, Juha Kaikko, Jouni Ritvanen

**Year:**

M.Sc. (Tech.) 1

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Docent, D.Sc. (Tech.) Jouni Ritvanen

**Aims:**

Upon completion of the course the student will be able to: 1. create stationary and time dependent mass, momentum and energy balances for various kinds of energy systems, 2. perform design tasks, utilize mathematical software in calculation, and analyze the characteristics of
energy systems, 3. include material property definitions into mathematical software or into own code when simulating energy systems, 4. create, solve and analyze the set of stationary and time dependent balance equations using Excel and MATLAB, 5. create, solve and analyze stationary energy systems with IPSEpro software package, and 6. create, solve and analyze time dependent energy systems with APROS software package.

**Contents:**

Advanced problems in the modelling of energy systems needed by engineers and researchers. The course lectures provide mathematical basis for problem formulation, and exercises providing a chance to work with various computational packages.

**Teaching Methods:**

1st period: 14 h of lectures and 14 h of case exercises. 2nd period: 12 h of lectures, 12 h of case exercises and 4 h of seminars. Individual work: Written assignments 52 h. Seminar work 48 h. Total individual work 100 h.
Total workload 156 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0 - 5. Written assignments 60 %, seminar work 40 %.

**Course Materials:**

Moodle.

**Prerequisites:**

BH20A0450 Heat Transfer, BH20A0800 Engineering Thermodynamics, BH40A1451 Fluid Dynamics II, or similar skills.

**Places for exchange-students? (Yes, number/No):**

max 10

**Places for Open University Students?(Yes, number/No):**

max 5

### BH40A1501: Turbulence Models, 4 cr

**Validity:** 01.08.2016 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Teemu Turunen-Saaresti

**Year:**

M.Sc. (Tech.) 2

**Period:**

3-4

**Teaching Language:**

English

**Teacher(s) in Charge:**

Associate professor (tenure track), D.Sc. (Tech.) Teemu Turunen-Saaresti

**Aims:**

Upon completion of the course the student will be able to recognize the characteristics of turbulence models and to estimate the suitability of different turbulence models for various fluid mechanical problems. In addition, the student will be able to interpret the physical basis and the theory of turbulence models.

**Contents:**

Navier-Stokes equations, RANS equations, Reynolds stress, eddy viscosity, algebraic, one equation and two equation models and advanced models.

**Teaching Methods:**

3rd period: 12 h of lectures, 12 h of tutorials. 4th period: 12 h of lectures, 12 h of tutorials. Homeworks 20 h, Project work 36 h.
Total workload 104 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5. Homeworks 30%, project work 70%.

**Course Materials:**

David C. Wilcox: Turbulence models for CFD.

**Prerequisites:**

BH70A0001 Numerical Methods in Heat Transfer or equivalent knowledge.

**Places for exchange-students? (Yes, number/No):**

max 5

**Places for Open University Students?(Yes, number/No):**

max 5

### BH30A2001: Computational Nuclear Thermal Hydraulics, 3 cr

**Validity:** 01.08.2016 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Juhani Vihavainen, Otso-Pekka Kauppinen

**Note:**

This course is available only to nationals of countries that have implemented adequate nuclear non-proliferation under the rules of the International Atomic Energy Agency (IAEA).

**Year:**

M.Sc. (Tech.) 1

**Period:**

4

**Teaching Language:**

English

**Teacher(s) in Charge:**

D.Sc. (Tech.) Juhani Vihavainen

**Aims:**

Upon completion of the course students will understand basic equations and special features in thermal hydraulic system code modelling. The students are able to use system codes introduced in this course, APROS and TRACE, and understand engineering design and modelling basis.

**Contents:**

Thermal hydraulic phenomena of nuclear power plant during normal operation and incident and accident situations. Calculation and modelling of a two phase flow in computer codes. Modelling of essential processes in nuclear power plants with APROS and TRACE software and CFD codes.

**Teaching Methods:**

Lectures 14 h, tutorials 14 h, assignment 40 h, preparation for the examination 7 h, written examination 3 h.
Total workload 78 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, examination 50 %, assignment 50 %.

**Course Materials:**

Lecture materials. APROS and TRACE code manuals, as applicable.
Todreas, Kazimi: Nuclear Systems I & II, as applicable.

**Prerequisites:**

BH30A0201 Nuclear Reactor Design and BH30A1901 Theoretical Nuclear Thermal Hydraulics.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

max 5

### BH30A2200: Experimental Nuclear Thermal Hydraulics, 3 cr

**Validity:** 01.08.2014 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Juhani Vihavainen, Otso-Pekka Kauppinen, Juhani Hyvärinen

**Note:**

This course is available only to nationals of countries that have implemented adequate nuclear non-proliferation under the rules of the International Atomic Energy Agency (IAEA).

**Year:**

M.Sc. (Tech.) 1

**Period:**

4

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, D.Sc. (Tech.) Juhani Hyvärinen

**Aims:**

Upon completion of the course the students will be able to describe basic measurement techniques for one- and two-phase flows, understand similitude and scaling, perform engineering design of downscaled models, understand the interaction between experiments and computer code calculations, describe advanced flow structure mapping techniques (e.g. wire mesh sensing, particle image velocimetry).

**Contents:**

Temperature, pressure, pressure drop, liquid level and flow measurement techniques. Void fraction measurement. Similitude, scaling principles. Model design. Designing experiments for computer code validation. Advanced flow structure measurement techniques.

**Teaching Methods:**

Lectures 14 h, tutorials 14 h, laboratory demonstrations 16 h, computer calculations 4 h, quiz 8 h, writing reports 22 h.
Total workload 78 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5. Quiz 25%, reports of laboratory works 75%.

**Course Materials:**

Ghiaasian: Two-Phase Flow, Boiling and Condensation, as applicable.

**Prerequisites:**

BH40A0701 Measurements in Energy Technology or equivalent course experience.

**Places for exchange-students? (Yes, number/No):**

max 5

**Places for Open University Students?(Yes, number/No):**

max 5

### BH40A1560: Fundamentals of Computational Fluid Dynamics, 6 cr

**Validity:** 01.01.2018 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F

**Year:**

M.Sc. (Tech.) 1

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Assoc. Prof. (tenure track), D.Sc. (Tech.) Teemu Turunen-Saaresti
M.Sc. (Tech.) Alireza Ameli

**Aims:**

This course acquaints students with the basic procedures of conducting computational fluid dynamics (CFD) simulations and the key numerical methods in heat and mass transfer. Students will be able to mesh problems efficiently and detect problems related to meshing and computational grids/meshes. Students are also be able to use numerical software(s) for the computation of simple cases, interpret and analyze gained results and explaintheory and limitations of studied numerical methods. In addition, students areable to form equations using the finite volume method. A CFD software is used to design simple engineering flow problems.

**Contents:**

Numerical solution methods for the conservation of mass, momentumand energy. Solutions for heat transfer problems including conduction,radiation and convection. The finite volume method. Formulation of discretized conservation equations. Differentiation methods. The solution of equation sets. Setting boundary conditions. Physics of flow problem. Different types of grids. Setting up steady and transient CFD simulations. Meshing. Solution procedures and techniques.Visualization techniques and post-processing the results.

**Teaching Methods:**

1st period: 12 h of lectures, 12 h of exercises. 2nd period: 12 h of lectures, 12 h of exercises. Homeworks 24 h. Project work 73 h. Preparing for the examination 8 h. Written examination 3 h.
Total workload 156 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

Yes

**Assessment:**

0-5. Homework 30%, Project work 40%, Exam 30%.

**Course Materials:**

Versteeg, H.K.: An introduction to Computation al Fluid Dynamics, The Finite Volume Method.

**Prerequisites:**

BM20A5001 Principles of Technical Computing or equivalent knowledge.

**Places for exchange-students? (Yes, number/No):**

Max. 10

**Places for Open University Students?(Yes, number/No):**

Max 10

### BH40A1570: Advanced Computational Fluid Dynamics, 5 cr

**Validity:** 01.01.2018 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F

**Year:**

M.Sc. (Tech.) 1

**Period:**

3-4

**Teaching Language:**

English

**Teacher(s) in Charge:**

Assoc. Prof. (tenure track), D.Sc. (Tech.) Teemu Turunen-Saaresti
M.Sc. (Tech.) Alireza Ameli

**Aims:**

The aim of the course is to acquaint students with the numerical simulations of multiphase and real gas flows, condensation, advance heat transfer (multi-fluid) and turbomachinery. After completing the course, students are able to simulate above-mentioned flow using a CFD software and write own functions to a CFD software. In addition, students are able to identify the limitations and simplifications of numerical simulations related to problems.

**Contents:**

Advanced topics of computational fluid dynamics. Multiphase flows. Real gasmodels. Condensation. Multi-fluid heat transfer. Turbomachinery. Meshing. Implementation of functions to a CFD software. Transient multi-domain simulation.

**Teaching Methods:**

3rd period: 12 h of lectures, 12 h of exercises. 4th period: 12 h of lectures, 12 h of exercises. Homeworks 24 h. Project works 58 h.
Total workload 130 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5. Homeworks 50% and project works 50%.

**Course Materials:**

Material in course's Moodle page. Notes done by the lecturers.

**Prerequisites:**

BH40A1560 Fundamentals of Computational Fluid Dynamics or equivalent knowledge.

**Places for exchange-students? (Yes, number/No):**

Max. 10

**Places for Open University Students?(Yes, number/No):**

Max. 10

## KoDSaManu: Modern Manufacturing, 20 - 30 cr

**Validity:** 01.08.2016 -
**Form of study:**
**Type:** Study module
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F

**Aims:**
After completing this minor subject the student will be able to:
- calculate manufacturing process parameter to metallic products to achieve successfully production in technically manner but also economically wise
- design total manufacturing order and overall process to achieve efficient production rate with old and new machines
- create total manufacturing chain from original distributor to end user
- listen, discuss, understand and negotiate with different people with different organizational level
- find and create new production solutions for rapidly changing world

After the studies, students:
- have a theoretical or practical capability to work international environment.
- will understand the importance of the production for the national economy.
- have a theoretical or practical understanding of overall manufacturing and supply chain process to understand deeply different workers role in production.
- have a theoretical or practical understanding of a queque, mathematical distribution and simulation theory used in job shops.
- have a theoretical or practical understanding of a normally used manufacturing process.

*Obligatory Studies 25 ECTS cr*

### BK50A4000: Production Processes in Modern Job Shops, 5 cr

**Validity:** 01.08.2016 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Juho Ratava, Mika Lohtander

**Year:**

M.Sc. (Tech.) 1

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Researcher, D.Sc. (Tech.) Mika Lohtander

**Aims:**

After completing the course, the students:
1. can choose the manufacturing processes for the most common products
2. are able to design a manufacturing order for a modern product
3. are able to evaluate manufacturing time and manufacturing costs based on basic mathematics.

**Contents:**

The course focuses production processes, material handling and storage methods needed in modern job shops. During the course, students become familiar with the basic metal industry processes as well as manual and automatic assembly processes. Individual works allows students to familiarize themselves to different kind of manufacturing processes. Students presents case-tasks to other students.

**Teaching Methods:**

Lectures 24 h, lecture exercises 12 h. Independent work like assignments and learning diary 94 h. Total workload 130 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, Lecture assignments 60 %, learning diary 40 %.

**Course Materials:**

Literature to be announced during lectures. Course material is available in the Moodle.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

max 5

**BK50A4100: Manufacturing Systems and Scheduling, 5 cr**

**Validity:** 01.08.2016 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Mika Lohtander, Esko Niemi

**Year:**

M.Sc. (Tech.) 1

**Period:**

3-4

**Teaching Language:**

English

**Teacher(s) in Charge:**

Reseacrher, D.Sc. (Tech.) Mika Lohtander

**Aims:**

After completing the course, the student:
1. is able to evaluate the most important production parameters like lead time and bottlenecks by means of simulation
2. is able to design fundamentals of the manufacturing systems
3. is able to evaluate manufacturing time and manufacturing costs based on manufacturing simulation
4. is able to make optimization for most common manufacturing environments.

**Contents:**

The course focus on production management and analysis methods needed in modern job shops. Production was analyzed by computational methods and manufacturing simulation is introduced and some case studies will analyzed. Example tasks are calculated and discussed in small groups. Every lecture includes its own exercise.

**Teaching Methods:**

Lectures 24 h, lecture exercise 24 h. Individual work 82 h. Total workload 130 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, activity during course 40 %, individual assigments 60 %.

**Course Materials:**

Literature to be announced during lectures. Course material is available in the Moodle.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

No

**BK50A4200: Product Flow in Job Shops, 5 cr**

**Validity:** 01.08.2016 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Energy Systems

**Grading:** Study modules 0-5,P/F

**Teachers:** Mika Lohtander

**Lectured every other academic year (Yes, next realization year/Leave empty):**

Yes, lecturing every socond year, next time in period 1. and 2. in year 2018-2019.

**Year:**

M.Sc. (Tech.) 2

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Researcher, D.Sc. (Tech.) Mika Lohtander

**Aims:**

After having passed the course, the student will:
1. is able to act as a product manager in a manufacturing plant
2. is able to analyze production capacity and to make improvement for production
3. is able to take responsibility for the daily operations of a production plant
4. is able to respond plant investments

**Contents:**

The course lectures will discuss the meaning of an overall function of a manufacturing flow. The course focuses to the strategy and methods of the production. Student will prepare and present during lectures, key factors and most common issues of production. In assignment, the students will plan and design factory lay-out commonly used in metal industry and present product flowin subcontracting network.

**Teaching Methods:**

Lectures 24 h, Group assignment and individual work 106 h. Total workload 130 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, lecture activity 40 %, assignment and individual work 60 %.

**Course Materials:**

Literature to be announced during lectures. Course material is available in the Moodle.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

No

**BK50A4300: Managing Job Shops, 5 cr**

**Validity:** 01.08.2016 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Mika Lohtander

**Note:**

The course will be lectured for the next time during the academic year 2019-2020.

**Lectured every other academic year (Yes, next realization year/Leave empty):**

Yes, 2019-2020.

**Year:**

M.Sc. (Tech.) 2

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Researcher, D.Sc. (Tech.) Mika Lohtander

**Aims:**

After having passed the course, the student will:
1. know the factory management duty and responsibility
2. is able to take responsibility for the daily operations of a production plant
3. know the stakeholders role for production

**Contents:**

The course lectures will discuss the meaning of overall function of manufacturing and stakeholder’s point of view. The topics cover everyday information technology, stakeholder cooperation and internal operation of the plant. A personal work will dealt more in-depth point of view to management.

**Teaching Methods:**

Lectures 24 h, individual work 106 h. Total workload 130 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, Activity during lectures and exercises 20 %, individual work 80 %.

**Course Materials:**

Literature to be announced during lectures. Course material is available in the Moodle.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

No

**BK50A4401: Fabrication Laboratory, 5 - 10 cr**

**Validity:** 01.08.2017 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Energy Systems
**Grading:** Study modules 0-5,P/F
**Teachers:** Mika Lohtander

**Note:**

Suitable also for doctoral studies.

**Year:**

M.Sc. (Tech.) 1-2

**Period:**

1-4

**Teaching Language:**

English

**Teacher(s) in Charge:**

Researcher, D.Sc. (Tech.) Mika Lohtander

**Aims:**

After having passed the course, the student will:
1. get touch some important research topics in field of manufacturing
2. be familiar how to transfer research result to practice
3. is capable to create or build simple and practical solutions.

**Contents:**

The course lectures will discuss the annually changing research themes. During the course the students will plan, design and in some cases built industrial systems. Students
will present their Project Work results to a public audience.

**Teaching Methods:**

Lectures 12 h, project work 118 h. Total workload 130 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, practical part of project work 50 %, theoretical part of project work 50 %.

**Course Materials:**

Literature to be announced during lectures. Course material is available in the Moodle.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

max 5

**Description and DL of the company assignment:**

During this particular course, industrial manufacturing related problems could be solved, as an engineering student assignments. Industrial cases could relate to an assembly, processes, automation, product flow, subcontracting or storage. Students can practice production related skill with simulation and optimization software.
Contact:
Mika Lohtander. mika.lohtander@lut.fi, +358 400 579 455

## TiDSOsedt: Software Engineering and Digital Transformation minor, 24 - 30 cr

**Validity:** 01.08.2018 -
**Form of study:**
**Type:** Study module
**Unit:** LUT School of Business and Management
**Grading:** Study modules 0-5,P/F

**Aims:**
Software Engineering and Digital Transformation Minor Learning Objectives
1. Describe and adapt software engineering knowledge, best practices, and standards appropriate to engineering complex software systems.
2. Analyze a problem; identify and elicit functional, non-functional and sustainability requirements appropriate to its solution.
3. Recognize human, security, social, entrepreneur issues and responsibilities relevant to engineering software and digitalization of services.
4. Acknowledge life-long learning as a way to stay up to date in the profession.

*Obligatory courses 12 cr*

### CT60A5500: Quality Assurance in Software Development, 6 cr

**Validity:** 01.01.2018 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Business and Management
**Grading:** Study modules 0-5,P/F
**Teachers:** Uolevi Nikula

**Year:**
M.Sc. (Tech.) 1
**Period:**
1-2
**Teaching Language:**
English
**Teacher(s) in Charge:**
Associate Professor, D.Sc. (Tech.) Uolevi Nikula

**Aims:**
After the course students are able to do the following activities in the key areas of software development based on the available research literature
1. name key activities and artifacts related to each area
2. develop standard documents for the given areas when relevant
3. describe typical problems occurring in each area
4. summarize typical ways to avoid the identified problems

In general the students have the knowledge to
5.plan and run a software project
6.assure the quality of software development
Students are able to
7.work collaboratively in a team

**Contents:**

Software economics, project management, process areas, tools, configuration and change management, teams, process assessment, improvement, and measurement.

**Teaching Methods:**

Lectures 14 h, exercises 14 h, assignments & self-study 14 h, team assignments 36 h, 1. period. Lectures 14 h, exercises 14 h, assignments & self-study 14 h, team assignments 36 h, 2. period. Total workload 156 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0 - 5. Weekly assignments 70 %, project 30%, no exam.

**Course Materials:**

Materials announced in the lectures. Basic reference is Robillard, Kruchten, and d'Astous: Software Engineering Process with the UPEDU, Addison-Wesley, 2002.

**Prerequisites:**

Software Engineering CT60A4002 or equivalent.

**Places for exchange-students? (Yes, number/No):**

max 10

**Places for Open University Students?(Yes, number/No):**

max 5

### CT70A2000: Requirements Engineering, 6 cr

**Validity:** 01.01.2018 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Business and Management
**Grading:** Study modules 0-5,P/F
**Teachers:** Sami Jantunen

**Year:**

M.Sc. 1

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

AssociateProfessor, D.Sc. (Tech.) Sami Jantunen

**Aims:**

At the end of this course students will be able to:
1. Perform requirements engineering in the context of the most common software development life cycles and processes
2. Develop effective functional and non-functional requirements that are complete, concise, correct, consistent, testable and unambiguous.
3. Select the appropriate requirements elicitation techniques to identify requirements
4. Effectively analyze requirements and prioritize accordingly.
5. Create a requirements specification to communicate requirements to a broad set of stakeholders
6. Manage change to requirements

**Contents:**

The focus of this course is in helping the student to choose and apply requirements engineering (RE) techniques to different types of software development situations. The course considers a variety of software development contexts such as bespoke software development, market-driven, and agile development and discusses how these contexts affect the choice of RE techniques. To this end, different RE-related techniques as well as different underlying principles and formats for documenting and maintaining requirements are covered.

**Teaching Methods:**

Lectures 14 h, homework 20 h, Period 1.
Lectures 14 h, homework 20 h, Period 2.
Individual studies, project assignments 88 h. Total 156 h

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

Yes

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, continuous evaluation (no Exam)
Assignments 50%, Weekly Mini-examinations 50%

**Course Materials:**

Elizabeth Hull, Ken Jackson, Jeremy Dick, Requirements Engineering. 2011. Springer, London. ISBN: 978-1-84996-405-0.
More material to be announced later.

**Prerequisites:**

No

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

No

*Elective courses, choose 12 cr*

**CT30A8922: User Experience Design, 6 cr**

**Validity:** 01.01.2018 -
**Form of study:** Basic studies
**Type:** Course

**Unit:** LUT School of Business and Management

**Grading:** Study modules 0-5,P/F

**Teachers:** Annika Wolff

**Note:**

NOTE: Can not be included in the same degree as CT30A8921 User and Design Research in Software Engineering.

**Year:**

M.Sc. 1

**Period:**

3-4

**Teaching Language:**

English

**Teacher(s) in Charge:**

Post-doctoral researcher, D.Sc Annika Wolff

**Aims:**

How do we design interactive technology, systems and services? Why do only a few of them make it to market and most fail? Why users are not able to master, learn and use them? What are the costs and benefits of user experience design? The course answers these questions while outlining the user research, user experience, user-centric design and design thinking approaches for software products, systems and services engineering. Through a mix of readings on human computer interaction (HCI) and design science research, user research investigations and a practical team-oriented design project in the living lab, students will acquire a solid practical and theoretical grounding in “user experience design methods and user interface design”.
The importance of human aspects in design and innovation is a key concern in software and information systems engineering and research. Design principles and methods can be used to increase the value of software products through the concept of open innovation. This course follows the work of open innovation and user-centric design and design thinking theories and principles that established the basis of innovation by design. It analyzes the concept of innovation by design, as it is applied to software and information system design, from the HCI (human-computer interaction), user experience and research perspective. Students will learn how to formulate a design as a problem space and how to use the UCD UXDT toolkit to create an innovative solution to solve the problem and conduct user testing. This course will teach students the design theories used in the interaction design, user-centered design (UCD) and user experience design thinking (UxDT) processes.
Via a design bootcamp in the CODER Living Lab, students will be able to:
[1]. Advocate and build-in support for interaction, user-centered and user experience design with stakeholders
[2]. Apply user research methods for identifying target users and their problem spaces
[3]. Use ideation techniques that go beyond brainstorming to propose innovative solutions, software products, services and systems
[4]. Conduct rapid prototyping to gather user feedback, inform design decisions and iteratively improve design solutions
[5]. Build and validate diverse forms of user interfaces including mobile, wearable, tangible and cyber physical user interfaces
[6]. Use usability testing and user acceptance methods to assess and validate proof of concept and prototypes
[7]. Integrate user experience design methods into the wider software development and innovation lifecycle.

**Contents:**

Design theories, principles and methods. Principles of design thinking. Human-centric design processes. User experience in design practices. Co-design in living lab. User research in design. Persona and customer profiling. Diary studies. HCI design patterns. Storytelling. Paper prototyping. Usability and sustainability testing. Controlled experiments. Design of innovative software products. Introduction to design research and science. Socio-technical systems design. Historical, cultural, and technical

foundations of design in a range of discipline areas (software engineering, HCI, arts). In a group of 6 students are asked to develop a design concept and validate it in the design living lab. Students are requested to demonstrate their capacity to generate design ideas, innovative concepts, proposals or solutions independently and/or collaboratively in response to a set briefs and/or as a self-initiated activity or based on documented user experiences.

**Teaching Methods:**

Weekly Design bootcamp sessions 24h. Lecture preparation (mandatory readings from textbooks and video to watch from HCI labs) 24h. Practical large design bootcamp in a group of 6 students' 48h. User research in living lab 36h. Prototyping and presentation of the design portfolio in the class 28 h. Total 160h.
Students will complete many hands-on activities and interact with their fellow students and representatives of real users as they experience a completely different way of learning how to develop human-centric software and information systems, services, and socio-technical systems.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

Grade: 0-5
Design Portfolio 60%
Individual reflections on design methods included in the design portfolio 20%
Oral group presentation of the final design concept and portfolio 20%

**Course Materials:**

Specific mandatory readings from the following books will be discussed in class by the professor and the students. The following are also suitable background readings:
• Tim Brown. Change by Design: How Design Thinking Transforms Organizations and Inspires Innovation
• Terry Winograd (ed.): Bringing Design to Software. Addison-Wesley, 1996. Bill
• Buxton, Sketching User Experiences: Getting the Design Right and the Right Design, Morgan Kauffmann Series on Interactive Technologies, 2007. Mads, et al. (Eds).
• The Online Encyclopedia of Human Computer Interaction, 2nd Edition. Interaction Design Foundation.
Students are required to read some chapters from these two books, the second is the mandatory textbook:
• User Interface design and evaluation. D. Stone, C. Jarrett, M. Woodroffe. S. Minocha. Morgan Kauffmann Series in Interactive technologies. 2005.
• Interaction Design: Beyond Human-Computer Interaction, 4th Edition, Jenny Preece, Helen Sharp, and Yvonne Rogers. February 2015, Wiley.

**Limitation for students? (Yes, number, priorities/Leave empty):**

36 max, places in the living lab

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

No

**CT60A5103: Software Engineering Models and Modeling, 6 cr**

**Validity:** 01.01.2018 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Business and Management

**Grading:** Study modules 0-5,P/F

**Teachers:** Antti Knutas

**Year:**

M.Sc. 1

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Post-doctoral researcher, D.Sc. Antti Knutas

**Aims:**

Software modeling (this course) is aimed at reducing the gap between problem and software implementation through the development and use of models, which describe complex systems at multiple levels of abstraction and from a variety of perspectives. A model is an abstraction (one aspect or entire system) of an existing or planned system. Models are created to serve particular purposes, for example, to present a human-understandable description of some aspect of a system or to predict its quality.
The course is focused at building a deep understanding of the concept of model and modeling while enabling the students to be able to:
1. Master the importance of conceptual modeling techniques in software engineering and the diverse types of models.
2. Explain the concepts of meta-models, platforms dependent and independent models, model-to-model transformations, automated code generation from models.
3. Understand and select the appropriate modeling method or methods for the software development project at hand and for the various types of software systems such as critical-safety systems, interactive consumer services, enterprise applications, hardware software, etc.
4. Manage, plan, analyze and contribute to various models to represent requirements, design, implementation and maintenance of large intensive software products, systems and services.
5. Understand how human, social and technical factors may have (both) positive and negative influence on the methods and practices of modelling in software engineering.
6. Identify the modeling challenges facing the software engineering research community as well as the avenues for further investigations.

**Contents:**

Modeling in Software Engineering Body of Knowledge (SWEBOK). Principles and foundations of software engineering. Formal methods. Prototyping techniques. Object-oriented modeling. Data-centric models. Model-driven architecture (MDA). Modeling techniques. Importance of modeling in software development projects and processes. Software engineering tools. Information, structure and behavioral modeling. Systematic literature review and large case studies on specific models and methods, their uses and abuses such as UML, use cases, user task models and prototypes, Z, B, and G Express. Systems Thinking

**Teaching Methods:**

Lectures/seminars on selected topics 24 h. Presentations 8h, weekly self-study 48 h (mandatory readings), scientific literature review and case studies 56 h, period 1-2. Research papers 20 h. Total 156 h.

The course is designed to be a forum for a scientific discussion and presentations by the professor, students and guests' researchers. Except an introductory lecture, the professor will be mainly acting as a senior project manager and a researcher will be advising students regarding literature review, reliable information sources on software engineering as well as how to select, review and present a case study

on software engineering methods. The students will have to work in a team of 2-3; each team will make 2 presentations in the class; each student will have to contribute to the writing of a research paper that can be submitted to a conference or a workshop. Altogether, the presentations provide a systematic framework for selecting the appropriate methods for complex software systems development projects.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

Grade: 0-5
Project in groups (6 deliverable) 60%
Pictorial research paper 30%
Participation in class 10%

**Course Materials:**

There is no book that covers all the topics addressed in the course. A selection of readings from top journals will be used as basic readings; students are requested to make their own literature review from IEEE Transactions on Software Engineering, IEEE Software, ACM Transactions on Software Engineering Methodologies, Journal of Software and Systems (JSS), Communication of the ACM. The students are encouraged to walkthrough, one of the two following books as a basic introductory reading:
(1) R.S Pressman. Software Engineering: A Practitioner's Approach, 7/e, McGraw Hill, 2010
(2) J. Sommerville. Software Engineering. 9/e, Addison Wesley, 2011.

**Limitation for students? (Yes, number, priorities/Leave empty):**

48.

**Places for exchange-students? (Yes, number/No):**

max 5

**Places for Open University Students?(Yes, number/No):**

No

### CT60A5400: Fundamentals of Game Development, 6 cr

**Validity:** 01.08.2016 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Business and Management
**Grading:** Study modules 0-5,P/F
**Teachers:** Jussi Kasurinen

**Year:**

M.Sc. (Tech). 1

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Docent, D.Sc. (Tech.) Jussi Kasurinen

**Aims:**

Intended Course Learning Outcomes. At the end of this course students will be able to:
1. Conduct independent work in entertainment software engineering context.
2. Independently design and implement a small-scale game program with some industry-relevant platform.
3. Acquiring further knowledge concerning the taught game development tool.
4. Working as a productive member and as part of a team developing larger entertainment software product.

**Contents:**

Applied software engineering course. The objective for this course is for students to learn how to use their software engineering knowledge in an entertainment software engineering context. With the selected game development tools, student is capable to independently design and develop a small game program on some modern game engine platform, or work as a part of a team developing a larger game product.
List of Topics: lectures and project works:
- Games as software products
- Basics of processes and models applied in the entertainment software industry
- Basics of the game development tools
- Introduction to game engines and their functions
- Basics of 3D objects
- Introduction to game development-related programming problem.
- Basics of artificial intelligence in entertainment software engineering context.
- Basics of sound engineering
- Gamification and Serious games.

**Teaching Methods:**

Primary mode of work is assisted self-study. Lectures 8 h, Independent work and project assignments 148 h. Total 156 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5. Continuous evaluation (no exam)
Project proposal and presentation 20%
Individual project assignments (x2) 60%
Peer review work on other project assignments 20%.

**Course Materials:**

Based on the yearly implementation; the taught game engine tutorials and other materials given during the course.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

15–

**CT60A7322: Software Business Development, 3 cr**

**Validity:** 01.08.2016 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Business and Management

**Grading:** Study modules 0-5,P/F

**Teachers:** Marianne Kinnula

**Year:**

M.Sc. (Tech.) 1-2

**Period:**

Intensive week 20

**Teaching Language:**

English

**Teacher(s) in Charge:**

Docent, Ph.D. Marianne Kinnula

**Aims:**

After completing the course, the student has knowledge of how to 1. develop a software business idea over the whole life cycle of the business, 2. conduct market and business analyses, 3. identify sources for financing the business, and how to 4. select a suitable business model for the company.

**Contents:**

The course introduces the concepts of business idea, business plan, software business models and strategies, and the software value network. Case studies vary yearly.

**Teaching Methods:**

Lectures 6 h, workshops 12 h, seminar presentations 8 h, homeworks and project (pre, course, post) 52h. Total amount 78 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, pre-task, project, essay.

**Course Materials:**

To be announced in course pages and in lectures.

**Limitation for students? (Yes, number, priorities/Leave empty):**

Yes, 40.

**Places for exchange-students? (Yes, number/No):**

max 5

**Places for Open University Students?(Yes, number/No):**

max 5

### CT70A4000: Business Process Modelling, 6 cr

**Validity:** 01.01.2018 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Business and Management

**Grading:** Study modules 0-5,P/F

**Teachers:** Ajantha Dahanayake

**Year:**

M.Sc. (Tech.) 1

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, PhD Ajantha Dahanayake

**Aims:**

1. Identify the principles of a business process modelling language and the dimensions of quality in a process model
2.Apply the process of process modelling (“method”) and the social aspects of process modelling
3.Use the modelling language to express and abstract from a realistic business process
4.Apply a method for modelling business processes in all its stages
5.Evaluate the model and the modelling process as a social process
6.Investigate a business and research question related to business process modeling

**Contents:**

Introduction of the concept and relevance of a business process, role modeling, dimensions of model quality and measurement, BPM and modeling methods, application to business process modeling and digital transformation, research issues.

**Teaching Methods:**

Lectures 14 h, homework work 20 h, 1. period.
Lectures 14 h, homework 20 h, 2. period.
Reading assignments, 2 hands on team project assignments 88 h. Total 156 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5. continuous evaluation.
Assessments 50%, Project 50%

**Course Materials:**

- Silver, Bruce: BPMN Method and Style, 2nd Edition, with BPMN Implementer's Guide: A structured approach for business process modelling and implementation using BPMN 2.0. Cody-Cassidy Press, 2011
- Weske, Mathias: Business Process Management: Concepts, Languages, Architectures. Springer, 2007

**Places for exchange-students? (Yes, number/No):**

max 5

**Places for Open University Students?(Yes, number/No):**

No

**CT70A5000: Impact and Benefits of Digitalization, 6 cr**

**Validity:** 01.01.2018 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Business and Management

**Grading:** Study modules 0-5,P/F

**Teachers:** Paula Savolainen

**Year:**

M.Sc (Tech.) 2

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

PhD Paula Savolainen

**Aims:**

The aim of the course is to give knowledge about different functions of an organization, which have to be considered when developing and following a digitalization strategy for the organization, and being able to assess the impact and benefits of digitalization.
After completing this course the student will be able to
1. Understand consequences of digitalization at macro level
2. Understand the ecosystem where the organization in question is operating and its' connections to the organization's business operations
3. Assess technologies from the viewpoint of the organization in question and how technologies enable new services / new ways of working for the organization
4. Develop an overall digitalization strategy or a project plan for an organization
5. Compile a perception of impacts for the organization in question and possibilities to achieve desired benefits
6. Evaluate research articles and write a reasoned opinion on the articles

**Contents:**

Drivers of digitalization; analysis of industry sectors, ecosystems, value networks and organizations; new business models; analysis of burning technologies; cost benefit analysis; from current state to unknown; impact of digitalization globally.

**Teaching Methods:**

Lectures 28 h, assignment given during the lectures (pair work) 10 h, self-study 10 h, reading and analyzing research articles (individual work) 30 h, project work (group work + report + presentation) 78 h. Total 156 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5. continuous evaluation
Assignment: report + presentation 40%
Project work: group work + report + presentation 60%.

**Course Materials:**

Reading package will be announced at the beginning of the course.

**Places for exchange-students? (Yes, number/No):**

max 5

**Places for Open University Students?(Yes, number/No):**

No

### CT70A7000: Digital Business Platforms, 6 cr

**Validity:** 01.01.2018 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Business and Management
**Grading:** Study modules 0-5,P/F

**Note:**

Not lectured in 2018-19, this course will start from academic year 2019-20.

**Year:**

M.Sc. (Tech.) 2

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

D Sc. (Tech) Kari Heikkinen, Professor Ajantha Dahanayake

**Aims:**

At the end of the course students will be able to
1. Have expertise of the fundamental principles of key enabling pillars and platforms for digital business
2. Understanding how different platforms will add value to digital business
3. Understanding how data analytics will enhance value of heterogeneous data
4. Understand the role of stakeholders, technology trends and business challenges of software technology for being able to build a customer-centric culture and customer understanding
5. Master a digital business platform help to reengineer existing services, business processes and creating new digital services

**Contents:**

Introduction to pillars of and platforms for digital business: IoT (Internet of Things), 5G and CPS (Cyber Physical Systems), Data and Analytics (Big data), Ecosystems (Cloud evolution and Software as a service), strategies (Cybersecurity) and technologies (Distributed Ledgers, e.g. block chain), Information Systems, Customer experience and Business platforms.
In-depth discussion of platforms examples from different industries for demonstrating the variety of possible approaches towards organizing and managing platforms. Identifying the patterns of technology and transformation underlying current and future platforms of digital business. Overview of the different design steps and important decisions in the development of a digital platform or in its selection for business needs.

**Teaching Methods:**

Lectures 28 h, Case studies with in-depth discussions 70 h, Course work 28 h, Essay preparation 30 h. Total workload 156 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5. Continuous evaluation
Class participation, discussions and quizzes = 40%
Written Case studies (in groups) = 40%
Scientific paper on future vision of digital platforms individual) = 20%

**Course Materials:**

"Platform Revolution: How Networked Markets Are Transforming the Economy - And How toMake Them Work," by G. Parker,  M. Van Alstyne, S. Choudary, 2016.
Handouts during the class

**Limitation for students? (Yes, number, priorities/Leave empty):**

Yes, 40, priority given to Digital Transformation students

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

No

## FyDInt300: Technical Physics, 20 - 26 cr

**Validity:** 01.08.2009 -

**Form of study:**

**Type:** Study module

**Unit:** LUT School of Engineering Science

**Aims:**
By the end of minor, the student:
- knows basic phenomenon in physics
- understands dependences and interactions
- is able to make experimental work in physics
- knows basic definitions and most important methods in physics

*A minimum of 20 ECTS cr should be selected from the courses below.*

### BM30A0500: Applied Optics, 6 cr

**Validity:** 01.08.2007 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Engineering Science

**Grading:** Study modules 0-5,P/F

**Teachers:** Erik Vartiainen

**Year:**

M.Sc. (Tech.) 1-2

**Period:**

2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Associate Professor, Ph.D. Erik Vartiainen

**Aims:**

After the course a student:
1. knows the basic properties of waves and wave motion,
2. understands the material polarization phenomenon as the ultimate source of light,
3. knows the basic properties and physics of laser action,
4. knows the ideas and applications of ultrafast optics,
5. knows the basic physics and applications of nonlinear optics,
6. knows the Fresnel-equations, and understand accordingly the physics of light reflection and refraction,
7. knows the basics of light polarization, the corresponding applications and the Jones matrix formulation,
8. understands the meaning of spatial and temporal coherence of light, and their implications for the technical applications, such as FTIR spectroscopy,
9. knows the ABCD-matrix formulation for geometrical optics,
10. knows the basics of laser imaging: one- and two-photon confocal microscopy, spectral imaging, and fluorescence nanoscopy,
11. understands the physics of producing slow and fast light, and knows their applications,
12. understands diffraction of light, and its applications.

**Contents:**

1. Wave motion and wave equations,
2. Maxwell equations and electromagnetic spectrum,
3. Lasers,
4. Ultrafast lasers,
5. Fresnell equations,
6. Polarization and optical activity,
7. Geometrical optics,
8. Coherence,
9. Interference and diffraction,
10. Nonlinear optics,
11. Optical microscopy and nanoscopy,
12. Slow and fast light, THz-optics,
13. Attosecond optics,
14. Coherent control.

**Teaching Methods:**

Lectures 42 h, exercises 14 h, homework 70 h, preparation for the exam 26 h and exam 4 h. total 156 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, examination 100 %.

**Course Materials:**

1. Eugene Hecht, Optics, 4th edition (Addison-Wesley, 2002). 2. G. R. Fowles, Introduction to Modern Optics, 2nd edition, (Holt, Rinehart and Winston, New York, 1976). 3. R. W. Boyd, Nonlinear Optics (Academic Press, San Diego, 1992). 4. Y. R. Shen, The Princples of Nonlinear Optics (Wiley, New York, 1984).

**Prerequisites:**

Students are recommended to have completed a basic course in physics.

**Places for exchange-students? (Yes, number/No):**

15–

**Places for Open University Students?(Yes, number/No):**

max 15

### BM30A1500: Advanced Topics in Material Science, 6 cr

**Validity:** 01.08.2007 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Engineering Science

**Grading:** Study modules 0-5,P/F

**Teachers:** Erkki Lähderanta

**Year:**

M.Sc. (Tech.) 1

**Period:**

2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, Ph.D. Erkki Lähderanta

**Aims:**

The aim of the course is to introduce students to selected topics of advanced Material Science: Nanophysics, Semiconductors, Superconductors, Magnetism, Ferroelectrics

**Contents:**

Nanophysics, applied superconductivity, ferroelectrics, magnetism, applied semiconductors and other advanced topics in material science connected to nanophysics.

**Teaching Methods:**

Lectures 30 h, homework 126 h (5 essays á 25 h 12 min), 2nd period. Total work load 156 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

Pass/Fail. Written assignment 100 %.

**Course Materials:**

Lecture notes to be given at lectures.

**Prerequisites:**

BM30A2200 Semiconductor and Superconductor Physics

**Places for exchange-students? (Yes, number/No):**

max 5

**Places for Open University Students?(Yes, number/No):**

max 5

### BM30A1600: Microelectronics, 6 cr

**Validity:** 01.08.2008 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Engineering Science
**Grading:** Study modules 0-5,P/F
**Teachers:** Erkki Lähderanta, Ekaterina Soboleva, Bernardo Barbiellini

**Year:**

M.Sc. (Tech.) 1

**Period:**

1

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, Ph.D. Bernardo Barbiellini
Junior Researcher, M.Sc.(Tech.) Ekaterina Soboleva

**Aims:**

Studentsget a good understanding of microelectronics basics and main integrated circuit(IC) components, students gain fluency to the most important variables and functions relatedto the IC components, and are able to apply their skills to analog IC design.

**Contents:**

Considering the basic components (PN junctions, metal-oxide-semiconductor, bipolar junction transistors, MOSFET, diodes, and amplifiers) of integrated circuit and their operation principles. Computation tasks and simulation to facilitate understanding.

**Teaching Methods:**

Lectures 28 h, exercises and tutorials 28 h, assignment 40 h, preparation for exam 60 h. Assignment and its presentation. Written examination.

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, examination 100 %. Satisfactorily completed assignment required.

**Course Materials:**

Roger T. Howe, Charles G. Sodini: Microelectronics An Integrated Approach.

**Prerequisites:**

Recommended BL40A1711 Johdanto digitaalielektroniikkaan and BL50A1400 Analogiaelektroniikka.

**Places for exchange-students? (Yes, number/No):**

max 5

**Places for Open University Students?(Yes, number/No):**

max 5

### BM30A1701: Physics of Semiconductor Devices, 6 cr

**Validity:** 01.08.2013 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Engineering Science
**Grading:** Study modules 0-5,P/F
**Teachers:** Tuure Tuuva

**Year:**

M.Sc. (Tech.) 2

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, Ph.D. Tuure Tuuva

**Aims:**

Student will acquire an in-depth knowledge of semiconductor diode, CCD, MOSFET, LED and photodiode and their operation.

**Contents:**

Structure, operation and physics of semiconductor devices.

**Teaching Methods:**

Special assignment 102 h, seminars 28 h, 1st-2nd period. Total workload 130 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

Pass/fail, seminar presentation 100 %.

**Course Materials:**

Sze, Physics of Semiconductor Devices.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

max 5

### BM30A2100: Microelectronics Processing Technology, 2 cr

**Validity:** 01.08.2009 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Engineering Science

**Grading:** Study modules 0-5,P/F

**Teachers:** Tuure Tuuva

**Year:**

M.Sc. (Tech.) 1

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, Ph.D. Tuure Tuuva

**Aims:**

To provide the student with a basic knowledge of microelectronics processing technology and components. Oxidation, diffusion and metallization.

**Contents:**

Purification of semiconductor materials. Growth of semiconductor crystals and wafer preparation. Epitaxial layers, diffusion, ion implantation, oxidation, etching and photolithography. Semiconductor manufacturing and development.

**Teaching Methods:**

Special assignment 52 h.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, seminar and/or written assignment 100 %.

**Course Materials:**

Plummer, J. D., Deal, M. D., Griffin, P. B., Silicon VLSI Technology: Fundamentals, Practice and Modeling.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

max 5

**BM30A2200: Semiconductor and Superconductor Physics, 6 cr**

**Validity:** 01.08.2009 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Engineering Science

**Grading:** Study modules 0-5,P/F

**Teachers:** Erkki Lähderanta, Egor Fadeev

**Year:**

M.Sc. (Tech.) 1

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, Ph.D. Erkki Lähderanta
Research Assistant, M.Sc. (Tech.) Egor Fadeev

**Aims:**

The course gives the student the skills to understand the basic behaviour of semiconductors and superconductors.

**Contents:**

Classical conductor, introduction to quantum mechanics, free-electron model of metals, energy bands, doped semiconductors, spintronics, basic properties of superconductivity, London equations, thermodynamics of the superconducting transition, the intermediate state, coherence length, current in superconductor, thin films, BCS-theory, type-II superconductors, high-Tc superconductors.

**Teaching Methods:**

Lectures 49 h, exercises 28 h, preparing for exercises 48 h, preparing for the exam 31 h. Total work load 156 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, examination 100 %.

**Course Materials:**

Lecture handouts.
Juha Sinkkonen: Puolijohdeteknologian perusteet.
A. C. Rose-Innes and E. H. Rhoderick: Introduction to Superconductivity, 2nd edition (Pergamon).

**Prerequisites:**

A knowledge of the fundamentals of material physics, a knowledge of the electric and physical properties of materials.

**Places for exchange-students? (Yes, number/No):**

max 5

**Places for Open University Students?(Yes, number/No):**

max 5

### BM30A2500: Nanophysics, 6 cr

**Validity:** 01.08.2014 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Engineering Science

**Grading:** Study modules 0-5,P/F

**Teachers:** Igor Rozhanskiy, Anton Komlev, Pavel Geydt

**Year:**

M.Sc. (Tech.) 1

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Junior Researcher, M.Sc. (Tech.) Pavel Geydt
Ph.D. Igor Rozhanskiy

**Aims:**

The objective of the course is to make information about the rapidly evolving areas of nanoscale science and technology available to a wide range of students. Upon completion of the course, students will clarify the principal difference between physical phenomena in macro-scale and nano-scale. Students will be able to:
- develop their understanding of bio-, physical and chemical systems,
- characterize the systems related with Materials science and Metrology,
- recognize the difference in prevailing forces in different size scales,
- explain many practical observations and anomalies found in their experimental research activity,
- apply this combined knowledge in practice.

After taking the course, students should become capable to operate safely with nano-systems, considering their hazardous aspects. The course helps to systematize the fragmented information about nano- related phenomena and knowledge from physical and chemical disciplines studied before.

**Contents:**

Nanoethics, Forces in the Nanoworld, Scaling Laws, Nanomaterials and Nanocomposites, Nanomechanics, Nanothermodynamics, Nanofluidics, Nanochemistry, Tribology, Nanooptics of Metals and Semiconductors, Nanoelectronics, Spintronics, Nanomagnetism, Nanocarbon, Nanolithography.

**Teaching Methods:**

Lectures 42 h, exercises 28 h; preparing for exercises 36 h, preparing for the presentation 8 h, preparing for laboratory works 6 h, preparing for the examination 40 h; 1st-2nd period. Total workload for student 160 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

Grade 0-5; evaluation 0-100 points, examination 50 %, exercises 25 %, presentation 15 %, laboratory works 10 %.

**Course Materials:**

Lecture handouts

**Prerequisites:**

B.Sc. (Tech) studies.

**Places for exchange-students? (Yes, number/No):**

max 5

**Places for Open University Students?(Yes, number/No):**

max 5

## MaDIntM300: Technomathematics, 20 cr

**Validity:** 01.08.2009 -

**Form of study:**

**Type:** Study module

**Unit:** LUT School of Engineering Science

**Aims:**

By the end of minor, the student is able to build mathematical models for some practical problems and is able to use computational methods to solve those.

*Choose a minimum of 20 ECTS cr*

### BM10A1100: Advanced Methods in Mathematics, Computing and Physics, 3 - 6 cr

**Validity:** 01.08.2016 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Engineering Science

**Grading:** Study modules 0-5,P/F

**Teachers:** Erkki Lähderanta, Arto Kaarna, Jouni Sampo

**Year:**

M.Sc. (Tech.) 2

**Period:**

1-4

**Teaching Language:**

English

**Teacher(s) in Charge:**

Associate Professor, D.Sc. (Tech.) Arto Kaarna, Professor, Ph.D. Erkki Lähderanta, University Lecturer, D. Sc. (Tech.) Jouni Sampo.

**Aims:**

The student is able to employ theoretical and operational skills in some specific area of applied mathematics, computing, and technical physics. The student is able to select, apply, and analyze methods to modeling problems in mathematics, science and engineering. Entrepreneurial learning methods are applied.

**Contents:**

The course consists of literature review, working on exercises and completing practical projects. Materials will be chosen and agreed individually according to the focus of the study module, students' interests, and research in the laboratories. The course with the same title can be included in the study programme twice when two distinct areas are covered.

**Teaching Methods:**

Self-study of learning materials, exercises, project assignment and reporting, seminar presentation, total 80-160 h, 1st-4th period.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

Pass/Fail, report and seminar presentation 100 %.

**Course Materials:**

Learning materials will be agreed with each student separately depending on the task(s).

**Prerequisites:**

Recommended: BSc. in Computational Engineering and Technical Physics, first year studies in the specialization of the M.Sc. studies.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

No

### BM20A3401: Design of Experiments, 4 cr

**Validity:** 01.08.2008 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Engineering Science

**Grading:** Study modules 0-5,P/F

**Teachers:** Heikki Haario, Marko Laine, Satu-Pia Reinikainen, Maaret Paakkunainen

**Note:**

Suitable also for doctoral studies.

**Year:**

M.Sc. (Tech.) 1-2

**Period:**

4

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, Ph.D. Heikki Haario

**Aims:**

After the course, the student is expected to master the basic skills for effective experimentation, together with regression analysis of data:
- understanding of the importance of designed experiments
- ability to apply the basic experimental plans, and regression techniques to analyse the results
- skills to optimize an engineering process using design of experiments and data analysis.

**Contents:**

Importance of experimental design, minimization of prediction uncertainty of regression models. Basic factorial designs: 2N, Central Composite designs for regression analysis. The Taguchi principles. Experimental optimisation of engineering processes.

**Teaching Methods:**

Lectures 21 h, exercises 14 h, homework 21 h, experimental work in laboratory 26 h, preparation for examination and the examination 22 h, 4th period. Total 104 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, examination 70 %, project work 30 %.

**Course Materials:**

Box, G., Hunter, S., Hunter, W. G.: Statistics for Experimenters, Wiley 2005, 2nd Edition.

**Prerequisites:**

First year university calculus, BM20A1401 Tilastomatematiikka I/basic statistics. Basic (Matlab) skills for technical computing with PC.

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

max 15

### BM20A5001: Principles of Technical Computing, 4 cr

**Validity:** 01.08.2014 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Engineering Science
**Grading:** Study modules 0-5,P/F
**Teachers:** Matylda Jablonska-Sabuka

**Year:**

B.Sc. (Tech.) 2., M.Sc. (Tech.) 1

**Period:**

1

**Teaching Language:**

English

**Teacher(s) in Charge:**

D.Sc. (Tech.) Matylda Jablonska-Sabuka

**Aims:**

Students get a good understanding of Matlab syntax and programming, gain fluency in principles of technical computing and are able to apply the skills to basic mathematical and engineering problems (the skills are applicable in big part to Octave and R programming, too).

**Contents:**

Working with various data structures (multidimensional arrays, cell arrays, etc.) and variable types (numeric, logical, textual, etc.), Matlab symbolic functionality, conditional statements (if-else, switch-case), loops (for and while), using built-in functions, handling external data, 2-D and 3-D plotting, writing user-defined functions, optimization of code speed, style and efficiency.

**Teaching Methods:**

Lectures 12 h, computer class exercises 24 h, independent study 30 h, preparation for exam 34 h, 1st period. Total 100 h. EXAM-tentti.

**Examination in Examination schedule (Yes/No):**

No

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

Yes

**Assessment:**

0-5, examination 100 %.

**Course Materials:**

Lecture material available in Moodle, based partly on textbook: Gilat, A.: An Introduction to Matlab with Applications.

**Prerequisites:**

Basic university calculus required. Recommended first year university calculus necessarily including matrix calculus.

**Places for exchange-students? (Yes, number/No):**

max 10

**Places for Open University Students?(Yes, number/No):**

max 5

### BM20A5100: Scientific Computing and Numerics for PDEs, 6 cr

**Validity:** 01.08.2011 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Engineering Science

**Grading:** Study modules 0-5,P/F

**Teachers:** Ashvinkumar Chaudhari

**Note:**

The course will be lectured every other year, next during the academic year 2019-2020. Suitable also for doctoral studies.

**Lectured every other academic year (Yes, next realization year/Leave empty):**

Yes, 2019-2020

**Year:**

M.Sc.(Tech.) 2

**Period:**

4

**Teaching Language:**

English

**Teacher(s) in Charge:**

Postdoctoral Researcher, D.Sc. (Tech.) Ashvinkumar Chaudhari

**Aims:**

The student knows basic equations of heat transfer, fluid flows and turbulence.The student is able to solve ordinary and partial differential equations usingthe finite difference/volume method, and is able to work with CFD simulationsoftware, such as OpenFOAM.

**Contents:**

Governing equations for fluid flow and heat transfer. Finite difference andvolume methods in heat transfer and fluid dynamics. Analytical solutions ofsimplified (linearized) flow problems. Numericalsolutions of steady state as well as time-dependent (i.e. non-linear) flow /heattransfer problems. CFD simulations for industrial flow problems.

**Teaching Methods:**

Lectures 14 h; Computer exercises (CFD software learning) 14 h; Mathematical exercises14 h, Self-study 40 h, Project assignment 40 h, Exam and preparation 10 h, 4thperiod. Total 132 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, project work 50 %, exam 50 %.

**Course Materials:**

Lecture notes

**Prerequisites:**

BM20A2701 Numerical Methods II
BM20A5500 Differentiaaliyhtälöt ja dynaamiset systeemit
BM20A4100 Vektorianalyysi teknillisessä laskennassa.

**Places for exchange-students? (Yes, number/No):**

max 5

**Places for Open University Students?(Yes, number/No):**

max 15

### BM20A6200: Inverse Problems and Normed Spaces, 6 cr

**Validity:** 01.08.2016 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Engineering Science

**Grading:** Study modules 0-5,P/F

**Teachers:** Jouni Sampo

**Year:**

M.Sc. (Tech.) 1

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

University lecturer, D.Sc. (Tech.) Jouni Sampo

**Aims:**

The student knows the concepts of function spaces and related basic terminology of functional analysis. Student understand and is able to use classical methods for solving linear inverse problems like of estimation of signal from incomplete or corrupted measurements.

**Contents:**

Vector spaces, bases and linear operators. Linear subspaces and projections. Norms, metric and convergence. Various function spaces, Banach spaces, Lp-spaces, Hilbert spaces. Formulation of inverse problems with additive noise. Ill-posedness and inverse crimes. Truncated singular value decomposition for inverse problems, Tikhonov and total variation regularization.

**Teaching Methods:**

Lectures 21 h, exercises 14 h, independent study and homework 40 h, 1st period. Lectures 21 h, exercises 14 h, independent study and homework 43 h, 2nd period. Exam 3h. Total 156 h.

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, exam 100 %

**Course Materials:**

Study material will be informed/distributed through the Moodle portal.

**Prerequisites:**

Basic Matlab skills are required (in 2nd period). BM20A1601 Matrix calculus is recommended.

**Places for exchange-students? (Yes, number/No):**

max 5

**Places for Open University Students?(Yes, number/No):**

max 15

### BM20A6500: Simulation and System Dynamics, 6 cr

**Validity:** 01.08.2017 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Engineering Science

**Grading:** Study modules 0-5,P/F

**Teachers:** Azzurra Morreale, Virpi Junttila

**Year:**

M.Sc. (Tech.) 1

**Period:**

2-3

**Teaching Language:**

English

**Teacher(s) in Charge:**

Post-Doctoral Researcher, D.Sc. (Tech.) Virpi Junttila
Post-Doctoral Researcher, Ph.D. Azzurra Morreale

**Aims:**

The course gives an introduction to the concepts of discrete and continuous simulation models and methods together with numerical examples. After the course, the student is able to create and use different simulation models to solve practical problems. Among the discrete-event based models, the student is able to model basic queuing, server, scheduling and storage size problems. Also, the student is able to create basic operations and model dynamic systems with Simulink and use Simulink to solve different simulation problems.

**Contents:**

Basic concepts of discrete and continuous systems. Model-based design, basic modeling work-flow, basic simulation work-flow, running the simulations and interpreting the results. Random numbers, discrete event generation by random numbers. Statistical and empirical distributions for event generation. Building numerical simulation examples with Matlab and Simulink. Modeling dynamics systems and simulation models for dynamic systems with Simulink.
Application examples: queuing systems, storage size optimization, profitability analysis, supply chain management, investment analysis

**Teaching Methods:**

Lectures 21 h, exercises 14 h, homework 21 h, 2nd period. Lectures 21 h, exercises 14 h, homework 21 h, 3rd period. Practical assignment 22 h, preparation for examination and the examination 22 h, 2nd-3rd period. Total 156 h.

**Suitability for doctoral studies (Yes/Leave empty):**

Yes

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, examination 80 %, homework and practical assignment 20 %.

**Course Materials:**

Course material is given in the course homepage.

**Prerequisites:**

Recommended BM20A1401 Tilastomatematiikka I and BM20A5001 Principles of Technical Computing.

**Places for exchange-students? (Yes, number/No):**

Yes, max. 5.

**Places for Open University Students?(Yes, number/No):**

max 15

### CS38A0060: Fuzzy sets and fuzzy logic, 6 cr

**Validity:** 01.01.2018 -

**Form of study:** Basic studies

**Type:** Course

**Unit:** LUT School of Business and Management

**Grading:** Study modules 0-5,P/F

**Teachers:** Pasi Luukka

**Year:**

M.Sc. (Tech) 2.

**Period:**

1-2

**Teaching Language:**

English

**Teacher(s) in Charge:**

Pasi Luukka, D.Sc. (Tech.), Professor

**Aims:**

By the end of the course student will be able to

- understand basic mathematical concepts related to fuzzy set theory and fuzzy logic
- model uncertain concepts using fuzzy set theory
- construct fuzzy models
- deduce meaningful information from fuzzy models

**Contents:**

The course consists of basics of fuzzy set theory, some algebras of fuzzy sets, fuzzy quantities, logical aspects of fuzzy sets, operations of fuzzy sets, fuzzy relations, fuzzy compositional calculus, aggregation operators, possibility theory, fuzzy inference systems.

**Teaching Methods:**

Lectures 14 h, tutorials 7 h, exercises 14 h, 1st period. Lectures 14 h, tutorials 7 h, exercises 14 h, 2nd period. Independent study 90 h. Written examination. Total workload 160 h.

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Assessment:**

0-5, examination 100 %.

**Course Materials:**

Klir, G., Yuan, B.: Fuzzy Sets and Fuzzy Logic. Theory and Applications, Prentice Hall, 1995.
Fullér, R.: Introduction to Neuro-Fuzzy Systems, Physica-Verlag, 2000.

**Prerequisites:**

Bachelor level mathematics courses:
BM20A6700 Matematiikka I, osa A , BM20A6800 Matematiikka II, osa A, BM20A6900 Matematiikka III
Experience in programming or using mathematical software required:
BM20A4301 Johdatus tekniseen laskentaan or BM20A5001 Principles of Technical Computing

**Number of exercise groups where enrollment is in WebOodi (Number/Leave empty):**

1

**Places for exchange-students? (Yes, number/No):**

max 10

**Places for Open University Students?(Yes, number/No):**

max 10

### CS38A0070: Fuzzy data analysis, 6 cr

**Validity:** 01.01.2018 -
**Form of study:** Basic studies
**Type:** Course
**Unit:** LUT School of Business and Management
**Grading:** Study modules 0-5,P/F
**Teachers:** Pasi Luukka

**Year:**

M.Sc. (Tech.) 2

**Period:**

3

**Teaching Language:**

English

**Teacher(s) in Charge:**

Professor, D.Sc. (Tech.) Pasi Luukka

**Aims:**

In the end of the course the student is expected to be able to

- understand theoretical aspects of data analysis
- understand basic mathematics from fuzzy set theory related to data analysis
- apply fuzzy set theory based models in data analysis
- analyze and interpret results from the models
- apply fuzzy principal component analysis, fuzzy clustering and classification methods to data analysis problems

**Contents:**

Fuzzy sets and relations. Uncertainty measures. Qualitative and quantitative analysis of fuzzy data. Principles of individual multi-person, multi-criteria decision making, feature selection, fuzzy principal component analysis, fuzzy clustering and classification, fuzzy regression analysis.

**Teaching Methods:**

Lectures 28 h, exercises 28 h. Practical assignment. Independent study 100 h. Total work load 156 h.

**Examination in Examination schedule (Yes/No):**

Yes

**Examination in Moodle (Yes/No):**

No

**Examination in Exam (Yes/No):**

No

**Number of mid-term examinations:**

No

**Assessment:**

0-5, examination 100 %. Practical assignment.

**Course Materials:**

Bandemer, H., Näther, W.: Fuzzy Data Analysis, Kluwer Academic Publ., 1992.

**Prerequisites:**

CS38A0060 Fuzzy sets and fuzzy logic

**Places for exchange-students? (Yes, number/No):**

No

**Places for Open University Students?(Yes, number/No):**

Yes, max 10