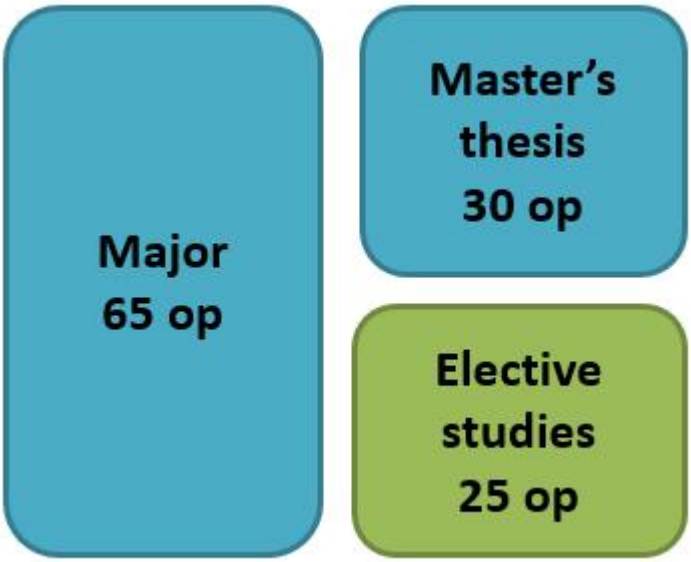
Master's Programme in Nano and Radio Sciences 2015-2016

Degree



At Aalto University School of Electrical Engineering students first complete the Bachelor of Science (Tech.) degree and thereafter the Master of Science (Tech.) degree.

The extent of studies is measured as ECTS credits. One academic year of full-time studies corresponds to 60 ECTS credits, which is equivalent to 1600 hours of work. The extent of the Master of Science (Tech) degree is 120 ECTS credits which mean two years of full-time studies.

Objectives for the Master's degree in the School of Electrical Engineering are stated in the degree regulations.

Structure

Studies leading to a Master's degree consist of

- Advanced studies 85–95 ECTS, including a Master's thesis (30 ECTS)
- Elective studies (25–35 ECTS)

The Major consists of advanced studies.

Objectives

The Master's Programme in Nano and Radio Sciences will offer a broad technical knowledge in an internationally recognized engineering field.

The student has an option to choose additional study entities which support their major. These studies can be selected from the wide selection of science, arts and business study portfolios offered at Aalto University.

The student forms an overview of professional practices within the major's study field. The student will be able to combine and link acquired knowledge to the relevant research fields. The students will attain a broad and deep understanding of his or her major. The student is able to perform scientific research and industrial R&D tasks, as well as fulfill international assignments in the field of the major.

Scientific practices and way of working

Having completed his or her Master's studies, the student will have the ability to develop further competencies through scientific doctoral studies and lifelong learning.

The student will have acquired scientific thinking practices and will be able to adapt these in his or her career. The student will also have a basic knowledge about innovation processes and entrepreneurship in the field of technical science.

The student will understand the theories and concepts related to his or her own field. Additionally, he/she will be able to apply those in the research and development tasks in the field of the major.

The student will know the lifespan of products and services related to his or her field. Furthermore, he/she will be able to participate on various engineering tasks related to the development and production processes.

The student will be able to choose and use appropriate methods and tools for design and performance evaluation. He/she will be able to critically observe the results, processes, and methods in the engineering work.

The student will know the main sources of information within his or her major and can acquire new knowledge to support his/her tasks.

After completing the Master level studies, the student will be able to design and develop complicated technical units belonging to large systems.

The student will be able to identify impact of technology on people, economy, society, and environment. He/she will be able to identify ethical questions and comprehend their significance in his or her work.

Professional competencies

During the Master level studies the student will have many opportunities to develop his/her skills in English. Furthermore, he/she will develop his/her oral and written communication skills.

The student, however, has the right to use Finnish or Swedish in his or her Master level studies according to the Finnish law.

The student will be able to work collaboratively in groups. In addition, the student will be able to contribute within an inter-disciplinary group also in an international environment.

Compulsory language studies

Compulsory language studies are included as part of the Finnish bachelor's degree for students who have studied in Finland and whose language of education is Finnish or Swedish. If the language studies have not been completed in the student's bachelor's degree, the student must take 2 ECTS in the second national language and 3 ECTS in one foreign language, including both oral and written proficiency.

Students who have received their education in a language other than Finnish or Swedish, or received their education abroad, are required to complete only 3 ECTS in one foreign language, including both oral and written proficiency. Relevant courses (marked with 'o' and 'w') are offered by the Aalto University Language Center. Alternatively, these students can choose 3 ECTS of Finnish courses, hence not covering the requirement of oral/written proficiency but meeting the language requirement of the degree.

Language studies are included in students' elective studies and are agreed in the personal study plan (HOPS).

Master's thesis

Students are required to complete a master's thesis, which is a research assignment with a workload corresponding to 30 credits. The thesis is written on a topic usually related to the student's major and agreed upon between the student and a professor who specializes in the topic of the thesis. The supervisor of the thesis must be a professor in the Aalto University. The thesis instructor(s) can be from a company or from another university. Thesis instructor(s) must have at least a master's degree.

Master's thesis work includes a seminar presentation or equivalent presentation. The student is also required to write a maturity essay related to the master's thesis.

The master's thesis is a public document and cannot be concealed.

Elective studies

Students choose 25-35 credits of elective studies. As elective studies, students can complete a minor and/or take individual courses. Individual elective courses can also be taken from other programmes at Aalto University or other Finnish universities through Flexible Study Right (JOO).

Entrepreneurial and multidisciplinary Aalto studies are recommended. Foreign students are encouraged to take Finnish courses.

Also studies completed abroad during student exchange can be included in the elective studies (exchange studies can also form an international minor or be included in the major). Work experience completed in Finland or abroad can also be included in Elective Studies.

Majors

Master's Programme in Nano and Radio Sciences offers five different majors:

- Advanced Materials and Photonics (65 ECTS)
- Micro- and Nanoelectronic Circuit Design (65 ECTS)
- Micro- and Nanosciences (65 ECTS)
- Radio Science and Engineering (65 ECTS)
- Space Science and Technology (65 ECTS)

Students should choose their major in the beginning of the programme. If unsure which major to choose, please contact your academic tutor or the Learning Services for advice. Major is confirmed by the approval of the personal study plan (HOPS).

Advanced Materials and Photonics

Pääaine suomeksi: Uudet materiaalit ja fotoniikka
Huvudämne på svenska: Nya material och fotonik
Code: ELEC3035
Credits: 65 ECTS
Responsible professors: Ilkka Tittonen, Erkki Ikonen, Esa Kallio, Harri Lipsanen, Hele Savin, Konstantin Simovski, Markku Sopanen, Zhipei Sun and Sergei Tretyakov

Objectives and learning outcomes

This major offers capabilities to work in a very broad range of challenges. The main goal is to give sufficient theoretical skills in physics, electromagnetic radiation, modelling, optics and in many materials-related topics. The major covers the basic theoretical courses required to master the general physical phenomena that are relevant ranging from nanosciences even to plasma and space physics. The curriculum of this major can be personalized according to student's particular field of needs and interests in the physical sciences.

The student is expected to gain such a good knowledge in natural sciences that it makes it possible to understand the basic physical and natural processes behind electronics, modern communication technologies and in nanosciences. This major gives excellent knowhow in materials science that is needed everywhere in industry. This major gives also an excellent starting point for doctoral studies by offering a deeper understanding of theory and applications. Gained mathematical and modelling skills are also seen important in many leadership positions.

Content of the major

Code	Course	ECTS	Teaching period
Compulsory courses common for the Programme; 25 ects			
ELEC-E0100	Introduction to Master's Studies at Aalto Elec	0	I-II
ELEC-E4110	Introduction to Nano and Radio Sciences	5	I-II
ELEC-E3120	Analysis and Design of Electronic Circuits	5	I-II
ELEC-E4130	Electromagnetic fields	5	I-II
ELEC-E3140	Semiconductor Physics	5	I-II
ELEC-E3150	Mathematical Methods	5	I-II
Elective courses; select 40 ects			

ELEC-E3210	Optoelectronics	5	III
ELEC-E3220	Semiconductor devices	5	III
ELEC-E3230	Nanotechnology	5	IV
ELEC-E3240	Photonics	5	V
ELEC-E3280	Micronova laboratory course	5	I-II (starting 2016)
ELEC-E3290	Micronova special assignment	5	III-V
CHEM-E5115	Microfabrication	5	III-IV
PHYS-C0220	Thermodynamics and Statistical Physics	5	IV-V
PHYS-E0414	Advanced Quantum Mechanics	5	I-II
PHYS-E0416	Quantum Physics	5	III-IV
PHYS-E0421	Solid-State Physics	5	IV-V
PHYS-E0422	Soft Condensed Matter Physics	5	III-IV
PHYS-E0435	Optical Physics	5	I-II
PHYS-E0436	Modern Optics V	5	IV-V (every other year, starting 2015)
PHYS-E0437	Laser Physics	5	IV-V (every other year, starting 2016)
ELEC-E4810	Metamaterials and Nanophotonics	5	I-II (starting 2016)
ELEC-E5730	Optics	5	III
ELEC-E4520	Space physics	5	IV-V

Micro- and Nanoelectronic Circuit Design

Pääaine suomeksi: Mikro- ja nanoelektroniikkasuunnittelu
Huvudämne på svenska: Mikro- ja nanoelektronikdesign
Code: ELEC3036
Credits: 65 ECTS
Responsible professors: Jussi Ryynänen and Kari Halonen

Objectives and learning outcomes

Integrated circuits are the enablers of the complex functionality embedded in all present day electronic devices. Combining logic, processors, memory, analog and digital signal processing and radio frequency communications electronics have provided miniaturiased implementations of functions that decades ago could not be even dreamed of. In future, it is envisioned that number of integrated circuits per person will continue to increase rapidly simply because the emerging ubiquitous intelligence in all areas of life can not be implemented without them. There is no application that could run without electronic hardware platform.

To be able to design integrated circuits for in embedded devices, the designers needs to handle not only the the theory of electronics, but also the design flow principles, tools, and understand the various abstraction layers of the design presentations. For example, designing he analog front-end amplifier that directly connects to brain sensor, or the RF front-end connecting to antenna, requires understanding of transistor and transmission line models for analog custom circuit and layout

design. On the other hand, implementing digital digital circuits, such as processors, DSP accelerators and high speed digital interconnects necessitate the knowledge on hardware efficient implementation methods of signal processing algorithms and good coding practices for hardware description languages, added with capability of efficient and highly automated usage of implementation and verification tool chains.

After completing the major the student knows the most common technologies used in the integrated circuit design. He understand the operation and theory of common circuits used in the circuit design. He knows the design tools used in the design flow and can utilize the functionalities of these programs. He understand the analog, RF and digital circuits. The optional courses in the major will complement student knowledge in the chosen field. The student is able to design integrated circuit blocks from specifications to producible layout.

Content of the major

Code	Course	ECTS	Teaching period
Compulsory courses common for the Programme; 25 ects			
ELEC-E0100	Introduction to Master’s Studies at Aalto Elec	0	I-II
ELEC-E4110	Introduction to Nano and Radio Sciences	5	I-II
ELEC-E3120	Analysis and Design of Electronic Circuits	5	I-II
ELEC-E4130	Electromagnetic fields	5	I-II
ELEC-E3140	Semiconductor Physics	5	I-II
ELEC-E3150	Mathematical Methods	5	I-II
compulsory courses for this Major; 30 ects			
ELEC-E3510	Basics of IC design	5	III
ELEC-E3520	Digital Microelectronics I	5	III
ELEC-E3530	Integrated Analog Systems	5	IV-V
ELEC-E3540	Digital Microelectronics II	5	IV-V
ELEC-E3550	Integrated RF-circuit	5	IV-V
ELEC-E3560	IC Design Project	5	IV-V
Elective courses; choose 10 ects according to the instructons below			

The 10 credits of technical courses can be chosen from any other major in the Master's programmes arranged in School of Electrical Engineering. These can include for example, radio engineering, signal processing, nanotechnology etc. If you want to include courses from other schools this must be agreed with professors in charge of this major.

Micro- and Nanosciences

Pääaine suomeksi: Mikro- ja nanotekniikka

Huvudämne på svenska: Mikro- och nanoteknik
Code: ELEC3037

Credits: 65 ECTS
Responsible professors: Markku Sopanen, Harri Lipsanen, Hele Savin, Zhipei Sun and Ilkka Tittonen

Objectives and learning outcomes

Having studied this major, the student is able to know and understand the properties of common and emerging materials used in micro devices, such as solar cells, LEDs, lasers, and nanoelectronic devices. The student also knows the major fabrication methods used to fabricate micro devices. In addition, the student knows where and how nanotechnology can be applied to enhance these devices.

The student understands the relevant mathematical concepts and principles used to model these devices. He understands the structural, electronic and photonic properties of the devices. The student understands the underlying physical principles and phenomena and the operating principles behind the micro devices.

Finally, the student is able to apply his acquired knowledge so that he can engage in international positions, multidisciplinary groups, or pursue doctoral studies in the field. Special assignments and Master's thesis provide the student a natural opportunity to analyse specific research problems.

Content of the major

Code	Course	ECTS	Teaching period
Compulsory courses common to the Programme; 25 ects			
ELEC-E0100	Introduction to Master's Studies at Aalto Elec	0	I-II
ELEC-E4110	Introduction to Nano and Radio Sciences	5	I-II
ELEC-E3120	Analysis and Design of Electronic Circuits	5	I-II
ELEC-E4130	Electromagnetic fields	5	I-II
ELEC-E3140	Semiconductor Physics	5	I-II
ELEC-E3150	Mathematical Methods	5	I-II
Compulsory courses for this Major; 30 ects			
ELEC-E3210	Optoelectronics	5	III
ELEC-E3220	Semiconductor Devices	5	III
ELEC-E3230	Nanotechnology	5	IV
ELEC-E3240	Photonics	5	V
ELEC-E3280	Micronova Laboratory Course	5	I-II (starting 2016)
ELEC-E3290	Micronova Special Assignment	5	I-V
Elective courses, select 10 ects			
CHEM-E5115	Microfabrication	5	III-IV
ELEC-E3250	Optical Fibers: Physics and Applications L	5	II
ELEC-E4810	Metamaterials and Nanophotonics	5	I-II (starting 2016)
ELEC-E5730	Optics	5	III

Radio Science and Engineering

Pääaine suomeksi: Radiotiede ja -tekniikka
Huvudämne på svenska: Radiovetenskap och –teknik
Code: ELEC3038
Credits: 65 ECTS
Responsible professors: Sergei Tretyakov, Antti Räisänen, Konstantin Simovski, Keijo Nikoskinen, Ari Sihvola, Katsuyuki Haneda and Ville Viikari.

Objectives and learning outcomes

Radio science and engineering is the basis of everything that transmits or receives electromagnetic waves, such as wireless communications devices, radars, or wireless sensors.

This major provides you with the ability to do high-level scientific research on new electromagnetic phenomena and to develop components and systems, or to invent new wireless gadgets, for the present and future wireless world.

Upon successfully finalizing the Radio Science major you will possess thorough knowledge of fundamental and applied electromagnetics, wireless devices and systems, and the related mathematical tools. This includes thorough understanding of radiowave propagation and interactions of electromagnetic fields and matter.

Furthermore, you will gain the ability to use this understanding for creating new components and systems for future wireless sensing and communications applications that are superior in their operation and have novel functionalities. This includes the ability to use analytical methods and numerical tools in the design of new components and circuits and to measure and evaluate the performance of components, devices and systems. So, you will have the proficiency to translate your expertise into new technological solutions for environmental, well-being, and communications challenges in the industry and academia.

Content of the major

Code	Course	ECTS	Teaching period
Compulsory courses common for the Programme ; 25 ECTS			
ELEC-E0100	Introduction to Master’s Studies at Aalto Elec	0	I-II
ELEC-E4110	Introduction to Nano and Radio Sciences	5	I-II
ELEC-E3120	Analysis and Design of Electronic Circuits	5	I-II
ELEC-E4130	Electromagnetic fields	5	I-II
ELEC-E3140	Semiconductor Physics	5	I-II
ELEC-E3150	Mathematical Methods	5	I-II
Compulsory courses for this Major ; 25 ECTS			
ELEC-E4410	Electromagnetic and circuit simulations	5	III
ELEC-E4420	Microwave engineering I	5	III-IV
ELEC-E4430	Microwave engineering II	5	IV-V
ELEC-E4440	Microwave engineering workshop	5	I-III

ELEC-E4450	Antennas	5	IV-V
Elective courses; 15 ECTS			
ELEC-E4710	Computational electromagnetics	5	IV-V
ELEC-E4720	Advanced circuit theory	5	IV-V
ELEC-E4730	Advanced field theory	5	IV-V
ELEC-E4740	Antennas workshop	5	I-II
ELEC-E4750	Radiowave scattering and propagation	5	I-II
ELEC-E4760	Terahertz techniques	5	V
ELEC-E4770	MIMO radios	5	IV-V
ELEC-E4810	Metamaterials and nanophotonics	5	I-II
ELEC-E4310	Wireless sensors	5	III-IV (starts in 2017)
ELEC-E4230	Microwave Earth observation instrumentation	5	I-II
ELEC-E4530	Radio astronomy	5	I-II
ELEC-E4910	Special assignment in radio science and engineering	5-10	any

Space Science and Technology

Pääaine suomeksi: Avaruustiede- ja tekniikka
Huvudämne på svenska: Rymdfysik och -teknik
Code: ELEC3039
Credits: 65 ECTS
Responsible professors: Anne Lähteenmäki, Esa Kallio, Jaan Praks and Tuija Pulkkinen.

Objectives and learning outcomes

In the only space science and technology major in Finland you can engage yourself in research challenges ranging from the birth of our universe to the physics of solar system dynamics, or in a rapidly growing number of services such as weather forecasts, navigation and telecommunication services, and environmental monitoring. Nanosatellite technologies have skyrocketing prospects to gain access to space at low cost and short time. Here you can join in high-profile space and science projects, get international experience, and learn team work and project management skills.

We have four focus areas: space technology, Earth observation, space physics and radio astronomy. These include, for example, building of satellite systems and space instruments, microwave instruments and techniques on airborne and spaceborne platforms for Earth observation, space weather satellite observations and numerical simulations of the Earth and other solar system objects, and r adio astronomical techniques, and the study of active galactic nuclei and galactic objects. The student can choose the study field(s) according to her/his academic or career interests.

Upon completion of the space science and technology major the student will be prepared for graduate education in one of the focus areas or for work in large space organizations, or for work in the industry or the public sector. The student will be familiar with space as environment for instruments and science, and people and the society, and what are the basic physical principles governing the processes in Earth observation, space physics, and radio astronomy. Furthermore, the

student will be able to design and build functional space systems and carry out space research and instrumentation projects, and do science with the results.

Content of the major

Code	Course	ECTS	Teaching period
Compulsory courses common for the Programme; 25 ects			
ELEC-E0100	Introduction to Master's Studies at Aalto Elec	0	I-II
ELEC-E4110	Introduction to Nano and Radio sciences	5	I-II
ELEC-E3120	Mathematical methods	5	I-II
ELEC-E4130	Electromagnetic fields	5	I-II
ELEC-E3140	Semiconductor Physics	5	I-II
ELEC-E3150	Analysis and Design of Electronic Circuits	5	I-II
Compulsory courses for this Major; 20 ects			
ELEC-E4210	Introduction to space	5	III and IV
ELEC-E4220	Space instrumentation L	5	I and II
ELEC-E4230	Microwave Earth observation instrumentation L	5	I and II
ELEC-E4240	Satellite systems L	5	IV and V
Choose two compulsory courses out of the following three; 10 ects			
ELEC-E4510	Earth observation L	5	III and IV
ELEC-E4520	Space physics L	5	IV and V
ELEC-E4530	Radio astronomy L	5	I and II
Elective courses; 10 ects			
ELEC-E4530	Radio astronomy L	5	I and II
ELEC-E4510	Earth observation L	5	III and IV
ELEC-E4520	Space physics L	5	IV and V
ELEC-E4920	Space technology project	5 - 10	All periods

ELEC-E4930	Special assignment in space science and technology	5 - 10	All periods
ELEC-E4420	Microwave Engineering I (from the Radio science and engineering major)	5	III-IV