

## Study plan: **PHYSICS - MASTER**

### **Name**

Bokmål: Physics - master  
Nynorsk: Physics - master  
English: Physics - master

### **Qualification awarded**

Master of Science in Physics.

### **Workload**

120 ECTS credits.

### **Learning outcomes**

*Knowledge – The candidate...*

- has a solid basis in physics in general
- has an advanced level of knowledge in one of the disciplines offered
- has knowledge about scientific methods in mathematics, statistics and physics

*Skills – The candidate...*

- is able to use scientific measurement equipment and carry out advanced experiments
- is able to evaluate and analyse measurement data
- is able to use programming tools for solving physical problems numerically
- is able to evaluate and analyse publicised theories, methods and experiments in the physics literature
- is able to work independently with problem solving

*Competences – The candidate...*

- displays good communication skills, orally and in writing, in the presentation of scientific work, both for a general public and for specialists in the field
- displays a good working habit, follows the code of ethics, and is able to continue a career within research, production, development and technical professions in the society

### **Admission requirements**

Admission to the Master's programme in physics requires a Bachelor's degree in physics, or another degree following a programme of study of not less than three years' duration, or similar education approved in accordance with the Norwegian Universities Act section 3-4.

In addition, specialisation in physics worth the equivalent of not less than 80 ECTS credits is required. Normally, an average mark of C or better is required in the Bachelor's degree or similar basis of admission.

### **Target group**

The Master's programme in physics is aimed at students holding a Bachelor's degree in physics or similar who are interested in pursuing a career in earth observation, electrical engineering, energy and climate, or space physics.

## **Programme description**

The Master's programme in physics offers specialisation in four disciplines:

- Earth Observation
- Electrical Engineering
- Energy and Climate
- Space Physics

### *Earth Observation*

The Earth Observation discipline teaches techniques for monitoring objects, surface classes, processes and parameters on the Earth with spaceborne and airborne instruments. Earth observation by satellite remote sensing provides large benefits to climate research, environmental monitoring and resource management, particularly in remote and uninhabited areas. The Earth Observation research group in Tromsø specialises in the analysis of satellite images for maritime and cryosphere applications in the High North.

The central location of Tromsø in the Arctic has led to substantial activity related to earth observation and remote sensing technologies. Today, around 250 people work with remote sensing in the Tromsø area, producing steadily increasing revenues, which makes it a sector of major economic importance. The Earth Observation group at UiT contributes to this development both through fundamental research and application development. The group has strong connections to the local companies, research institutes and users of satellite images, as well as to international research institutes. The cross-disciplinary collaboration with these actors is vital in the design of useful tools for applications such as oil spill detection, ship detection, sea ice charting and glacier monitoring. The Earth Observation group possesses a large archive of satellite data and ground truth data, and has access to powerful computing facilities.

The objective of the Earth Observation discipline is to teach the techniques used in satellite remote sensing of the Earth, with a focus on environmental monitoring. The tools are drawn from various fields such as signal and image processing, pattern recognition, applied statistics and physics. The aim is further to deliver candidates to the earth observation community, providing competent workers to all levels of the value chain, from users of remote sensing data in resource management and decision-making bodies to industry companies, research institutes and academia.

### *Electrical Engineering*

Electrical engineering provides solutions to the ever-increasing technological demands of modern society. In Tromsø, electrical engineering education is based on a strong research group, especially with respect to data analysis and signal processing methods and sensor technology. There are good facilities for optics and microwave laboratory work.

In data analysis and signal processing, the Electrical Engineering group has contributed advanced information theoretic machine learning methods for classification and automated grouping of data items, as well as sophisticated algorithmic tools for analysis of non-stationary stochastic processes with special emphasis on music. In research on sensors, the group has developed nano-sized waveguides, ultrasound transducer technology and microwave antennas for hyperthermia.

The Electrical Engineering group covers a wide range of application areas, some of which are the oil and gas sector and bio-medical physics and imaging:

- The petroleum oil and gas industry is of key national importance. The majority of the remaining petroleum resources are located offshore northern Norway, leading to new challenges with respect to equipment operating in a cold and harsh climate. The Electrical

Engineering group is leading a consortium of research institutions and oil companies performing research on and development of the next generation cold-water subsea sensors. Petroleum activity in the north also poses environmental issues since spills may affect one of Europe's most important breeding areas for fish. The Electrical Engineering group is developing data analysis methods for early detection of errors in the petroleum production line.

- Bio-medical physics and imaging research in the Electrical Engineering group is concentrated on development of new antenna concepts capable of both producing hyperthermia and receiving extremely weak radiated electromagnetic waves containing information on the tissue temperature distribution (microwave radiometry). Hyperthermia is an anti-tumoral therapeutic modality. It consists of selective heating of tumors to temperatures above 42 degrees Celsius, while maintaining healthy tissue nearer to physiological temperatures.

### *Energy and Climate*

This discipline offers specialisation in three different fields of research:

- Climate dynamics
- Fusion plasma physics
- Solar energy and energy storage

Students following the climate dynamics specialisation will acquire knowledge about the Sun's variability and its effect on Earth's climate system, and assess its importance compared to the anthropogenic causes of climate change. The research work in the Master's thesis will emphasise statistical analysis of solar variability, climate data, and dynamic and stochastic modelling of solar and climate processes aimed at testing various hypotheses about the primary drivers of climate variability.

Students following the fusion plasma physics specialisation will acquire a high level of knowledge on fluid dynamics, plasma physics, turbulent motions, energy transport, and numerical calculations. Candidates with these skills are highly desired in the scientific research sector and industry nationally and abroad. The Sun and other stars are powered by the energy released from fusion of hydrogen into helium. For more than half a century, there has been a large international research program focused on the development of controlled thermonuclear fusion for production of clean electrical energy on Earth. If successful, this will provide humankind with electrical energy for millennia. The fusion process requires so high temperatures that the matter is in the state of a plasma. In a reactor, this plasma will be confined by strong magnetic fields.

Students following the solar energy and energy storage specialisation will acquire in-depth insight into the nature of this source of energy, and how it can be exploited for the benefit of humankind. In particular, candidates will be trained to understand the physics and mathematics behind solar energy conversion. The student will learn how various materials harvest solar energy on a nanoscale all the way to how to design complete solar energy systems and importantly, how energy can be stored. For intermittent energy sources like solar energy to be widespread, successful and game changing it is crucial to have good energy storage possibilities. These storages do need to have large capacities as well as having a very fast response time.

## *Space Physics*

Tromsø is in a unique geographical position to study the Aurora Borealis and the upper Polar atmosphere, and we have long traditions since the early 1900's within this field of research. The Auroral Observatory in Tromsø formed the original basis of the physics studies at UiT The Arctic University of Norway. Today, the activities have been extended to research on the solar corona, the Sun-Earth interaction, and the upper atmosphere. Researchers at the Department of Physics and Technology work with data from the EISCAT (European Incoherent SCATter) radars and other instruments at Ramfjordmoen, Svalbard, and Andøya, with numerical modelling, and with laboratory experiments (Aurolab).

The Northern (and Southern) Lights are manifestations of space weather that has its origin in the variability of the Sun's activity. Most auroras occur as a result of huge solar magnetic explosions (solar mass ejections and solar flares) that enhance the solar wind and solar radiation arriving at the Earth. The scales of the perturbations that follow (geomagnetic storms) vary from the size of the Earth's magnetotail (about 200 Earth radii) to the fine structure of the aurora (tens of meters) at 100-200 km height above the Earth's surface.

As a student on the Master's degree programme in physics, you can choose one-year projects on a range of topics, for example:

- Observations with EISCAT of phenomena in the upper polar atmosphere, e.g. ion instabilities, fine structures in the aurora, and space weather (dynamics).
- Analysis and interpretation of EISCAT and other radar observations.
- Experimental, theoretical and numerical studies of dusty plasmas in the mesosphere with rockets, mesospheric and EISCAT radars.
- Theoretical and numerical analysis of turbulence and transport in space- and laboratory plasma.
- Experimental studies of plasma phenomena in laboratory plasmas.

## **Requirements for the independent work**

The Master's thesis corresponds to a workload of 60 ECTS credits and must be submitted within a deadline set in connection with approval of the supervision contract. After handing in the Master's thesis, it is assessed, and normally within 6 weeks an oral presentation and examination is held, that may influence on the final mark. The Master's project must be carried out on an individual basis.

## **Teaching**

The courses in the study programme have varied forms of instruction, typically lectures, exercises, laboratory work, computer work, or combinations of these.

Special curricula, project papers and the Master's thesis are supervised on an individual basis by the department's academic staff, possibly in collaboration with external companies or institutions by agreement.

## **Programme structure**

### *Earth Observation*

Compulsory courses in the Earth Observation discipline:

- FYS-2006      Signal processing
- FYS-2010      Digital image processing
- FYS-3001      Earth observation
- FYS-3012      Pattern recognition
- FYS-3023      Environmental monitoring from satellite
- FYS-3900      Master's thesis in physics

Courses on 2000-level should preferably be completed already in the Bachelor's degree, leaving more room for other optional courses on 3000-level.

Generally recommended optional courses in the Earth Observation discipline:

- FYS-2007 Statistical signal theory
- FYS-3011 Detection theory
- STA-2002 Theoretical statistics
- STA-3001 Computer-intensive statistics
- STA-3002 Multivariable statistical analysis
- STA-3003 Nonparametric inference

Optional courses should be determined in collaboration with your supervisor in connection with choice of research topic in the Master's thesis. Other optional courses may be approved on application or if recommended by your supervisor. An individual special curriculum or project paper may also be part of the degree.

If the Master's thesis involves work in a laboratory, in the field or on a research cruise, it is mandatory to conduct a course in safety education prior to commencing the thesis.

#### *Electrical Engineering*

Compulsory courses in the Electrical Engineering discipline:

- FYS-2006 Signal processing
- FYS-2007 Statistical signal theory
- FYS-2008 Measurement techniques
- FYS-3900 Master's thesis in physics

Courses on 2000-level should preferably be completed already in the Bachelor's degree, leaving more room for other optional courses on 3000-level.

Generally recommended optional courses in the Electrical Engineering discipline:

- MAT-2201 Numerical methods
- FYS-2010 Digital image processing
- FYS-3001 Earth observation from satellites
- FYS-3007 Microwave techniques
- FYS-3009 Photonics
- FYS-3011 Detection theory
- FYS-3012 Pattern recognition
- FYS-3023 Environmental monitoring from satellite
- FYS-3024 Biomedical instrumentation and imaging

Optional courses should be determined in collaboration with your supervisor in connection with choice of research topic in the Master's thesis. Other optional courses may be approved on application or if recommended by your supervisor. An individual special curriculum or project paper may also be part of the degree. At least 20 ECTS credits of optional courses must be at 3000-level.

If the Master's thesis involves work in a laboratory, in the field or on a research cruise, it is mandatory to conduct a course in safety education prior to commencing the thesis.

### *Energy and Climate*

Students are required to choose at least one of the following courses:

- MAT-3213 Climate dynamics
- FYS-3026 Fusion plasma physics
- FYS-3028 Solar energy and energy storage

Optional courses should be determined in collaboration with your supervisor in connection with choice of research topic in the Master's thesis. Other optional courses may be approved on application or if recommended by your supervisor. An individual special curriculum or project paper may also be part of the degree.

If the Master's thesis involves work in a laboratory, in the field or on a research cruise, it is mandatory to conduct a course in safety education prior to commencing the thesis.

### *Space Physics*

Compulsory courses in the Space Physics discipline:

- FYS-2009 Introduction to plasma physics
- FYS-3003 Cosmic geophysics
- FYS-3900 Master's thesis in physics

Courses on 2000-level should preferably be completed already in the Bachelor's degree, leaving more room for other optional courses on 3000-level.

Recommended optional courses approved in the Space Physics discipline:

- FYS-3000 Introduction to satellite and rockets techniques and space instrumentations
- FYS-3002 Techniques for investigating the near-earth space environment
- FYS-3017 Experimental methods in laboratory and space plasma

Other optional courses approved for Space Physics:

- \* AUT-2006 Elektronikk
- FYS-2008 Measurement techniques
- FYS-2017 Sustainable energy
- FYS-2018 Global climate change
- FYS-3001 Earth observation from satellites
- FYS-3007 Microwave techniques
- FYS-3009 Photonics
- FYS-3011 Detection theory
- FYS-3012 Pattern recognition
- FYS-3023 Environmental monitoring from satellite
- \* INF-2200 Datamaskinarkitektur og -organisering
- \* INF-2201 Operativsystem
- \* MAT-2100 Kompleks analyse
- MAT-2200 Differential equations
- MAT-2201 Numerical methods
- MAT-2202 Optimization models
- MAT-2300 Algebra 1
- MAT-3113 Nonlinear partial differential equations
- MAT-3114 Algebraic topology
- MAT-3200 Mathematical methods

- STA-2001 Stochastic processes
- \* STA-2003 Tidsrekker

\* = Currently only offered in Norwegian.

Optional courses should be determined in collaboration with your supervisor in connection with choice of research topic in the Master's thesis. Other optional courses may be approved on application or if recommended by your supervisor. An individual special curriculum or project paper may also be part of the degree.

If the Master's thesis involves work in a laboratory, in the field or on a research cruise, it is mandatory to conduct a course in safety education prior to commencing the thesis.

### Study plan table

#### *Earth Observation*

S2	FYS-3900 Master's thesis in physics (30 of 60 ECTS credits)		
A2	FYS-3900 Master's thesis in physics (20 of 60 ECTS credits)	FYS-3023 Environmental monitoring from satellite (10 ECTS credits)	
S1	FYS-3900 Master's thesis in physics (10 of 60 ECTS credits)	FYS-2010 Digital image processing (10 ECTS credits)	FYS-3001 Earth observation (10 ECTS credits)
A1	FYS-2006 Signal processing (10 ECTS credits)	FYS-3012 Pattern recognition (10 ECTS credits)	Optional course (10 ECTS credits)

#### *Electrical Engineering*

S2	FYS-3900 Master's thesis in physics (30 of 60 ECTS credits)		
A2	FYS-3900 Master's thesis in physics (20 of 60 ECTS credits)	Optional course (10 ECTS credits)	
S1	FYS-3900 Master's thesis in physics (10 of 60 ECTS credits)	FYS-2007 Statistical signal theory (10 ECTS credits)	Optional course (10 ECTS credits)
A1	FYS-2006 Signal processing (10 ECTS credits)	FYS-2008 Measurement techniques (10 ECTS credits)	Optional course (10 ECTS credits)

### Energy and Climate

S2	FYS-3900		
A2	Master's thesis in physics (60 ECTS credits)		
S1	MAT-3213 Climate dynamics (10 ECTS credits)	or	FYS-3026 Fusion plasma physics (10 ECTS credits)  and Optional courses (20 ECTS credits)
A1	Optional courses (30 ECTS credits)		

### Space Physics

S2	FYS-3900	
A2	Master's thesis in physics (60 ECTS credits)	
S1	FYS-3003 Cosmic geophysics (10 ECTS credits)	Optional course (20 ECTS credits)
A1	FYS-2009 Introduction to plasma physics (10 ECTS credits)	Optional course (20 ECTS credits)

### Assessment

Form of assessment varies, but most examinations are portfolio assessments of a take-home exam, project paper or laboratory report, in combination with a final oral or written exam. In some courses, mandatory assignments have to be approved for access to the exam.

### Language of instruction

Language of instruction is English and all of the syllabus material is in English. Examination questions will be given in English, but may be answered either in English or in a Scandinavian language.

Also the Master's thesis may be written either in English or in a Scandinavian language.

### Internationalisation and exchange possibilities

Exchange studies abroad or at the University Centre in Svalbard can be recognised in the Master's degree if recommended by your supervisor, and only if the external courses are validated prior to departure.

### Syllabus

Syllabus and reading list will be prepared for each individual course and presented at the start of studies.

**Other regulations**

The Faculty of Science and Technology has developed supplementary regulations for the Master's programmes.

The study programme is evaluated every year according to the university's quality assurance system. The courses in the study programme are evaluated every third time they are given, as a minimum. Course evaluation consists of both student and teacher reports.