PhD STUDY HANDBOOK FOR THE FACULTY OF NATURAL SCIENCES 2020-2021

The PhD programmes are standardized to 180 credits (3 years) including academic and methodological schooling, amounting to 30 credits. The residual 150 credits, which constitute by far the largest and most important part of the research education, are devoted to the research project carried out under academic supervision.

The Faculty of Natural Sciences offers the following PhD programmes:

• PhD in Biology

• PhD in Biophysics

• PhD in Biotechnology

• PhD in Chemistry

• PhD in Chemical Engineering

• PhD in Physics

• PhD in Materials Science and Engineering

• PhD in Medical Technology - Hosted by the Faculty of Medicine and Health Sciences. For more information about the programme: http://www.ntnu.edu/studies/phmedt

Admission requirements

Applicants for the PhD programmes at the Faculty of Natural Sciences must have a relevant master's degree or equivalent education, with a strong academic record.
Applicants are required to have a weighted average grade of B or higher (in accordance with NTNU's grading system) in the two last years of their master's degree (equivalent to 120 ECTS credits). Before you can apply for admission to one of the PhD programmes, the funding of the study period including running costs, must be confirmed.

Application for admission

All PhD candidates need to apply to be enrolled in a PhD programme by filling out an application form. The main supervisor and the Department give their recommendation before the application is approved by the PhD Programme Council. Admission to all the programmes is decided by the Faculty of Natural Sciences. It is required that you apply for admission no later than 3 months after you are employed. Applications to the PhD programmes can be submitted at any time.

Required coursework

The PhD education programme has a prescribed duration of three years of full-time study (180 ECTS credits). A minimum of 30 ECTS credits (equivalent to six months of fulltime study) have to be covered by required coursework. The training plan has to consist of courses within natural sciences or technology.

A minimum of 20 ECTS credits have to be PhD courses at NTNU, or from equivalent programmes at other academic institutions in Norway or abroad.

The course MN8000 “Doing Science: Methods, Ethics & Dissemination” is mandatory for all PhD candidates at the Faculty of Natural Sciences.

Exception: this requirement is not applicable for the PhD candidates admitted to the PhD programme in Medical Technology.

The remaining 10 credits can consist of an Individual Study Syllabus or advanced-level Master's courses. An Individual Study Syllabus should have a minimum of 3 credits, and should not overlap with existing courses. The Syllabus must be on a PhD-level and should be within the Professor`s subject area. The Syllabus is to be approved by the PhD Programme Council well before the planned examination.

Advanced courses with varying content (for example "Advanced Biology"), must in general be followed by minimum three candidates. Course description and examination will be the same in each realization. Several realizations with the same course code can be arranged simultaneously.

Courses must be weighted with a minimum of 3 credits to be approved as a part of the organized training plan for PhD.

Candidates must apply to make changes in the approved training plan. The application must be prepared together with the main supervisor and be recommended by the PhD Programme Council.

Assessment

All the courses or academic training approved for the PhD programmes require a final assessment in form of an exam, report or other assessments.

Examination of PhD courses at the Faculty is assessed by a mark passed/not passed, where passed correspond to a score of 70 points on a scale from 0 to 100. Approved courses from other faculties will follow the grading scale at those faculties.

Master courses must be passed with the grade A or B. A candidate who has passed the examination in a course with a grade lower than B is only entitled to retake the exam once.

Supervision

The main supervisor of the PhD candidate is normally employed at the Faculty of Natural Sciences, either as full or adjunct professor or as assistant professor. Any deviation from this regulation has to be recommended by the Research Committee at the Faculty for Natural Sciences and be approved by the Dean.

As a general rule, the PhD candidate is to have at least one co-supervisor. Co-supervisors must have a PhD degree. Post docs, researchers and professor emeritus may act as co-supervisors based on a recommendation from the Head of the Department where the PhD programme is based.

The Faculty may appoint one or more mentors who do not meet the qualification requirements for supervisors.

Other requirements

A project description, submitted no later than 6 months after enrolment in the PhD programme is mandatory for all PhD candidates.
As a part of the quality assurance of the PhD programmes, the PhD candidates are also required to respond to an annual progress report to address possible deviation in the progress.

Other information

Admission must be formalised in a written agreement: "Agreement concerning admission to the organised PhD programme". The agreement should be signed by the candidate, supervisors, the Department, the Faculty and by any external institutions involved.

Compulsory for all the PhD candidates is a PhD information day arranged in the beginning of each semester. Relevant topics for this seminar are: Ethics, Human-Resources, PhD-studies – the administrative process and Popular disseminations.

The Research Committee at the Faculty of Natural Sciences

The Research Committee serves as an advisory body for the Dean and the Faculty Board. The primarily task of the Committee is the following-up of the Faculty's research strategy, serving as an advisory body for grants of research sabbaticals and prioritizing applications for research equipment.
The Research Committee has an overall responsibility for the PhD education, including quality control of admission and implementation of candidates in the PhD programmes.

PhD Programme Council

The PhD Programme Councils are primarily an advisory commission for the Dean, the Head of Department and The Research Committee. The PhD Programme Council is responsible for suggesting the academic content, structure and implementation of relevant study programmes within the adopted guidelines and directions, delegated from the Dean.

The PhD Programme Councils are chaired by:

- PhD Programme in Biology: Professor Thorsten Hamann
- PhD Programme in Biotechnology: Professor Berit Løkensgard Strand
- PhD Programme in Biophysics: Professor Catharina de Lange Davies
- PhD Programme in Chemistry: Professor Øyvind Mikkelsen
- PhD Programme in Chemical Engineering: Professor Magnus Rønning
- PhD Programme in Materials Science and Engineering: Professor Knut Marthinsen
- PhD Programme in Medical Technology: Professor Hans Torp
- PhD Programme in Physics: Professor Catharina de Lange Davies

Information, forms, rules and regulations concerning the PhD education at the Faculty of Natural Sciences: http://www.ntnu.edu/nv/phd

Contact information:

PhD Programme in Biology and Biotechnology:
Executive Officer Maja C. Haaker, maja.haaker@ntnu.no

PhD Programme in Chemistry and Chemical Engineering:
Higher Executive Officer Lise Skorstad, lise.skorstad@ntnu.no

PhD Programme in Materials Science and Engineering:
Higher Executive Officer Elin S. I. Kaasen elin.s.kaasen@ntnu.no

PhD Programme in Physics and Biophysics:
Senior Executive Officer Anne Sæther, anne.sether@ntnu.no

The Faculty of Natural Sciences:
Senior Executive Officer Anne Sæther, anne.sether@ntnu.no
Higher Executive Officer Elin S. I. Kaasen, elin.s.kaasen@ntnu.no

Description of the PhD program in Biology:

General purpose and aim of the program

The main purpose of the PhD program in Biology is to educate independent researchers familiar with leading edge methods and/or technologies, having experience to collaborate at the national and/or international level and capable of performing original research.

The PhD program aims to meet current and future needs for expertise in research, development and dissemination in the university sector and in both public and private institutions, businesses and organizations. The PhD program in Biology will produce research scientists qualified for research activities and other work that requires a high level of scientific understanding. The candidate completes an independent research project leading to a thesis of high professional quality. The candidate will learn critical thinking, research ethics, relevant methods for research, analysis of scientific results, communication of knowledge and collaboration.

Areas of research

The PhD program hosts PhD students undertaking their research projects in different areas both within and outside the department/NTNU. Examples for outside host institutions are NINA and SINTEF. The department itself has a broad academic profile in biology, with interactions between organisms and their natural environment as an overriding focus. The department has currently 38 associate or full professors organized into 6 different sections (centre for biodiversity dynamics, marine science, cell and molecular biology, animal physiology, environmental toxicology, multiscale biology). We have a special responsibility for basic biological research and the broad application of knowledge in social and economic development. The department has extensive research activities, within many biological disciplines, including several leading-edge international research programs. Doctoral studies in biology can be undertaken in the following research areas actively pursued at the department for biology: Molecular biology, biotechnology, systems biology, plant physiology, animal physiology, environmental toxicology, ecotoxicology, behavior, evolutionary biology, aquatic or terrestrial ecology, biodiversity, natural resources, population genetics, aquaculture, marine biology and systematics.

The department's website provides more information about research and expertise existing in the department:

http://www.ntnu.edu/biology/research

General learning outcome of the program

The PhD program will provide training in how to generate and disseminate new knowledge and strengthen candidates' professional expertise in their respective fields.

Learning outcomes

A candidate who has completed a PhD degree in Biology should have the following learning outcomes:

Knowledge

Upon completion of the PhD program in biology, it is expected that the candidate

- is in the forefront of knowledge in their biological field of specialization, and can critically assess the limitations of current knowledge in the respective field of research
- master relevant theory, challenges and methods.

- critically assess the appropriateness and application of various methods and processes in research and professional development
- contribute to the development of new knowledge, new theories, methods, interpretations and documentation in biology.

Knowledge is generated by:
- attending courses equivalent to 30 ECTS credits
- reading and keeping abreast of the literature in the field
- performing research at a high level of independence.

Skills
Upon completion of the PhD program in biology, it is expected that the candidate can
- formulate research questions and plan and implement research
- conduct research of high scientific quality at an international level
- handle complex technical issues and challenge established knowledge and practice in the field
- combine insights from several disciplines
- can disseminate results from scientific research both in written and oral form

Skills are obtained through:
- supervision of the candidate by experienced supervisors
- the candidates´ engagement in supervision activity of students
- work with publications, submission to international journals and experience with the review process
- the dissertation
- presentation of results at national and international meetings and conferences

General competence
Upon completion of the PhD program in biology, it is expected that the candidate can:
- identify new relevant ethical issues and pursue research with professional integrity
- risk assess their operations and maintain health, safety and environment
- manage complex multidisciplinary assignments and projects
- disseminate research and development by recognized national and international channels
- participate in debates in international fora
- assess the need for, initiate, and drive innovation
- conduct original research of high quality at an international level
- transfer and apply their knowledge to meet the needs of the community
- establish professional networks
- appreciate the importance of the UN sustainability concepts and objectives and contribute to their successful implementation (Examples: sustainable production of food and energy)

Admission requirements

Admission to the PhD program requires a broad academic background in biology or other relevant subjects. In line with the requirement for a "strong academic background" it is required that the master's program (similar to the last two years of biology studies) are conducted with average grades of B or better (or equivalent qualification).

More information, application forms and PhD agreement etc. can be found here:
http://www.ntnu.edu/nt/phd/admission

Funding

Financing of the PhD study must be established prior to admission to the PhD program in biology.

Required coursework or other academic training

The course component corresponds to at least one semester of full-time study (30 ECTS credits). The main purpose is to give the student general, theoretical knowledge in biology, as well as to provide the theoretical scientific basis needed for the dissertation. The currently available PhD courses in the Department of Biology are summarized in the list below:

BI8002 Advanced methods in biosystematics
BI8012 Systems Biology: Examples from current literature
BI8022 Temperature physiology
BI8031 Plant ecology III
BI8040 Logical Modeling for Experimental Design in Biotechnology and Biomedicine
BI8060 Bio-optical characteristics and pigments in plants, algae and marine invertebrates
BI8061 Biological oceanography
BI8071 My AOP – Advances Outcome Pathways in Environmental Toxicology
BI8082 Evolutionary and ecological genetics
BI8091 Advanced biology
BI8081 Advanced conservation biology

Participation of candidates in PhD courses offered by other academic institutions is encouraged.

The course MN8000 Doing Science: Methods, Ethics and Dissemination constitutes a compulsory part of the training component. The faculty provides basic training in ethics, safety and innovation through a mandatory introduction program for PhD candidates.

Description of the PhD program in Biotechnology:

Description

The PhD program in Biotechnology is organized research training (doctoral program), educating independent researchers at an international level in cooperation with national and international research groups and institutions. The overall aim of the program is to contribute to the United Nations sustainability goals by training researchers and develop research based knowledge via relevant research projects.

The faculty has a broad academic profile in biotechnology. Research is conducted in collaboration within and between research groups at the faculty, in both basic and applied research. The academic community has an extensive and broad research activity, where several disciplines within biotechnology are represented, including some international cutting-edge areas.

The PhD program aims to meet current and future needs for competence in research, development and dissemination at the university, public and private institutions, businesses and organizations.

The PhD program in Biotechnology qualifies for research activities and related work that requires a high level of scientific understanding. The candidate performs an independent research project leading to a thesis at a high professional level. The candidate will learn critical thinking, dissemination of knowledge and collaboration.

Research areas

Doctoral work provides core expertise in one of the following research areas:

- Biopolymers and Biomaterials
- Microbial Biotechnology
- Food Science
- Analysis and Control of Microbial Systems

See the website of Department of Biotechnology and Food Science for further information about the subject areas: https://www.ntnu.edu/ibt/research

Subject areas at Department of Biological Sciences in Ålesund are also relevant: https://www.ntnu.no/iba/forskning

Overall learning objectives for the PhD program

The PhD program will provide training in how to generate and publish new knowledge, and strengthen the candidates' professional expertise within their academic field.

The organized research training (doctoral program) will be at a recognized and international level. It will provide direct personal experience in relevant experimental research, and specialization within key areas of biotechnology.

Learning outcome

A candidate with a completed PhD degree should have the following learning outcomes defined by knowledge, skills and general competence:

Knowledge

Upon completion of the PhD program in Biotechnology, it is expected that the candidate;

- is in the forefront of knowledge in their field of specialization in biotechnology, and can assess the limitations of current knowledge within this academic field
- can master scientific theory, problems and methods within the academic field of biotechnology
- can assess the appropriateness and application of relevant methods and processes in research and development projects
- can contribute to the development of new knowledge, new theories, methods, interpretations and methods of documentation within this academic field

Knowledge obtained through:

- *the program's mandatory course component of 30 credits (ECTS)*
- *read and keep themselves updated on the literature in the academic field*
- *thesis summary; the candidate has independently written an introduction that provides the background of the research, discusses and justifies the choices and use of methods, and puts the completed results into an international perspective*

Skills

Upon completion of the PhD program in biotechnology, it is expected that the candidate;

- can formulate problems, plan and conduct research and development within biotechnology
- can perform relevant modelling or experimental research and development in biotechnology at a high, international level
- can deal with complex scientific questions and challenge established knowledge and practices within the academic field

Skills obtained through:

- *supervision and own research*
- *work on publications, submission to international journals and experience with referee statements*
- *dissertation*
- *presentation of results at national and international meetings / conferences*

General knowledge

Upon completion of the PhD program in biotechnology, it is expected that the candidate;

- can identify relevant ethical issues, and perform research with professional integrity
- can risk assess their operations and maintain a high standard of health, safety and environment aspects in their work

- can handle scientific questions where the candidate works in scientific teams
- is able to establish professional networks with both Norwegian and international researchers
- can convey research and development and present scientific work by publishing in recognized international journals within the academic field and at national and international conferences
- can participate in debates within the academic field in international fora
- can assess the need for, initiate and drive innovation

General competence achieved through:

- *supervision and own research*
- *work with publications and thesis*
- *trial lecture; acquire knowledge about a given topic within a short time, scheduling, search / select / evaluate / process information, oral presentation*

Admission requirements

Admission to the PhD program requires a broad professional background in biotechnology and other relevant subjects. In line with regulation requirements for a "strong academic background", both the Bachelor's program (or the first three years of an integrated, five-year master) and the Master's degree (or the last two years of an integrated, five-year master) must be completed with satisfactory results; the applicant must have an average grade of B or better in the master's degree (or equivalent qualification).

Funding requirements

The financing of the PhD study must be established prior to admission to the PhD program in Biotechnology

Mandatory course component

The course component corresponds to at least one semester full-time study (30 credits). The main purpose is to give the student general, scientific theoretical knowledge in biotechnology, as well as to provide the theoretical scientific basis needed for the dissertation.

At least one of the courses offered by the Department of Biotechnology and Food Science must be chosen as part of the program's course component. The course MN8000 Doing Science: Methods, Ethics and Dissemination constitute a compulsory part of the training component.

The faculty provides an introduction to ethics, HSE and innovation through a mandatory introduction one-day program for PhD candidates.

Description of the PhD programme in Biophysics 2020-2021

Description of the academic programme

The PhD program in biophysics aims to educate independent researchers at a high international level in cooperation with national and international research communities, thereby fulfilling both current and future requirements for competence in research, development, and dissemination at universities, other public and private institutions, companies, and organizations.

Subject areas

The physics department covers a broad range of research subjects. We have a particular responsibility for fundamental research, as well as applications of knowledge within the development of industry and society.

The programme provides opportunities for various specializations within the fields of biophysics and medical technology, including biopolymers, bionanotechnology, microfluidics, Monte Carlo simulation of biophysics systems, radiation biophysics, nanoparticles and cancer therapy, clinical use of multiphoton microscopy, magnetic resonance imaging.
For a more detailed description of research areas, see the department website:
https://www.ntnu.edu/physics

Overall learning goals

The Ph.D. programme aims to educate and train candidates with knowledge and skills in biophysics, enabling the generation of new knowledge to the benefit of society. Especially, to fulfil United Nation's sustainability development goals to improve health by developing new diagnostic tools and therapies. The Ph.D. candidates will obtain general and field-specific expertise in biophysics, making them able to contribute to the advancement of the field of biophysics.

Learning outcome

A candidate who has completed the PhD programme in biophysics should have the following learning outcomes defined in terms of knowledge, skills, and general competence:

Knowledge

The candidate:

- is at the forefront of knowledge within his or her field of biophysics, bionanotechnology and/or medical physics which allows for development of future needs within the fields
- has the knowledge to apply physics to biological systems
- has knowledge within advanced experimental methods and/or computational biophysics

The knowledge is gained through:

- *formal training of 30 credits*
- *reading and keeping up to date on the literature within the field.*

- *performing and analysing own research*

Skills

The candidate:

- can formulate problems for, plan and carry out research and scholarly development work
- can use the research methods of the field to create new knowledge, new theories and methods
- can carry out research and scholarly research work of a high international standard
- can handle complex academic issues and challenge established knowledge and practice in the field
- can apply theories and methods of physics to understand how biological systems work

The skills are achieved through:

- *formal training of 30 ECTS credits*
- *guidance and own research*
- *preparing publications, submitting them to international journals, and gaining experience with referee reports*
- *writing the thesis and placing the results in a broader context.*

General competence

The candidate:

- can identify new relevant ethical issues and carry out his or her research with scholarly integrity
- can assess the risks involved in the work, and safeguard HSE
- can manage complex interdisciplinary assignments and projects
- can communicate research and development work through recognized national and international channels
- can participate in debates in the field in international forums
- can quickly acquire new knowledge
- can establish academic networks

General competence is acquired through:

- *various courses, especially the compulsory course Doing Science: Methods, Ethics and Dissemination*
- *a basic training in ethics, HSE and innovation*
- *own research*
- *working with publications and writing the thesis*
- *presenting results at national and international meetings and conferences*
- *giving a trial lecture on an assigned topic*

Requirements for admission, from § 5

To be admitted to the PhD programme a broad background in physics and other relevant fields is required. A master in physics or equivalent is required. In accordance with the regulations' requirement of a "strong academic background" it is required that both the previous bachelor studies (equivalent to the first three years of the technology programme) and the master studies (equivalent

to the final two years of the technology programme) are completed with satisfactory results. Normally an average grade of B or better for the master degree (or equivalent).

Finances

Funding for the studies must be available before admission to the PhD programme in biophysics.

Required courses

The course part of the programme is equivalent to one full semester of courses (30 credits). The main goals of this part are to give the candidate a general, scientific background in physics and biophysics, and to give the theoretical background required to perform the work.

Normally, a minimum of 15 credits should be within biophysics- or physics-related courses.

PhD candidates within biophysics perform their research within very varied fields. It is therefore important that all the candidates have a background that is relevant and sufficient for their research. It is recommended that the courses are selected so that the candidates get both a breadth within biophysics, as well as course work relevant for their particular research.

The Faculty provides training in ethics, HSE and innovation, through a mandatory introduction programme for PhD candidates. In addition, the course MN8000 Doing Science: Methods, Ethics and Dissemination constitutes a compulsory part of the training component.

Description of the PhD program in Chemistry:

General purpose of the program

The PhD programme in chemistry has as aim to educate independent researchers on an international level, in collaboration with national and international research institutions.

The programme has a broad profile, including several disciplines in chemistry. The activity is organised in three research groups. They include organic chemistry (synthesis and studies of organic molecules and materials), theoretical chemistry and thermodynamics (understand the structure, movement and reactions of molecules, modelling as well as calculations and studies of complex chemical molecules at equilibrium and non-equilibrium conditions) as well as studies in environmental and analytical chemistry.

Areas of research

This basic research is founded on solving and being in alignment with the UN Development Goals within health, energy and environment, and may be applied to problems in medical technology, energy conversion, nano-technology, marine and environmental chemistry, and such applications are also part of the activity. The methods and techniques used in the program are relevant for applications in the industry and the society at large. The research groups, which include world renowned investigators, have extended international collaborations.

The purpose of the PhD programme is to contribute to national needs for competence in research, this being in the industrial sector, in public and private research institutions as well as in the public sector, as teacher in the higher education system or governmental research institutions.

The work on the PhD thesis will lead to competence in the research front in one of the following

fields

* Organic chemistry

* Theoretical Chemistry

* Thermodynamics

* Environmental and analytical chemistry

The Department homepage gives further information on the research fields, see

http://www.ntnu.edu/chemistry

The PhD programme has as aim to train the candidate in the generation and publication of new knowledge, and to strengthen the candidate's general competence in the chosen research field. By completing the requirements of the PhD degree in chemistry the candidate shall have the following knowledge, skills and general competence:

Knowledge

Upon the completing of the PhD degree in chemistry, it is expected that the candidate

* is in the research front of the specialty field of chemistry, and can evaluate limitations of current knowledge in the field

* masters the relevant theory, problem formulations and methodologies at a broad and advanced level to allow for future flexibility in the field

* can evaluate suitability and application of various methods and processes in chemistry for research and development purposes

* can contribute to development of new knowledge, new theories or methods, and

interpretations or methods of documentation in chemistry

Knowledge will be achieved through:

** The passing of courses amounting to 30 credit points*

** Continuous reading of the field's scientific literature*

** The thesis work, where the candidate independently has written an introduction to the work,*

that gives the background for the research, sets it in an international perspective and gives the rational for the methods used

Skills

At the time of the thesis defence, it is expected that the candidate:

* can formulate problems necessary to plan and carry out research at advanced levels in chemistry and to create new knowledge, new theories and methods

* can perform research on a high international level

* can handle complex scientific questions and challenge established knowledge within the specialty field of chemistry

* can combine insights from different fields

Skills will be achieved through:

** supervision and own research*

** work with the publication(s) of the thesis and the international publication process, handling*

of reviews etc.

** presentation of results in internal, national and international meetings/conferences*

General competence

At the time of the thesis defence, it is expected that the candidate can:

* perform original research at a high international level

* carry out responsible research and innovation with scientific integrity in accordance to international and national legal and ethical statutes and guidelines

* assess risks of own activity for health, environment and safety of self and others

* direct complex inter-/multidisciplinary project work and assignments

* disseminate research and development-results through well reputed national and international channels, in oral and written ways

* participate in discussions within the field in international fora

* evaluate and initiate actions of innovative character and acquire new knowledge

* transfer and use knowledge in a way that meets the need of the society

* establish and work with peers in networks

General competence is achieved through:

** supervision and own research*

** work on publications and thesis*

** the trial lecture; documenting the ability to learn a new topic in an allotted, short time and present the results.*

Admission requirements

In order to be admitted to the PhD programme the candidate must document a strong background in the chemistry and in other relevant disciplines. A strong background should, according to the PhD regulations, be understood as a Bachelor degree (or an equivalent thereof) with average grade C or better, plus a Master degree (or an equivalent thereof) with grade B or better.

Financial requirements

Financing of the PhD study must be available before the student is accepted to the PhD programme.

The course part

A set of courses is included in the programme corresponding to one semester full time studies (30 credit hours). The main purpose of the course programme is to give the candidate a broader basis for the work on the thesis (in terms of scientific methods and ethics) plus the necessary theoretical fundament for the thesis work. The course MN-8000 "Doing Science: Methods, Ethics and Dissemination" (7,5 credits) is a mandatory part of the PhD programme. PhD courses offered at Department of chemistry are listed below. Candidates from department of chemistry are required to study at least one of these topics.

Description of the PhD program in Chemical Engineering

General programme description

The PhD programme in chemical engineering at NTNU provides organised research training in the research areas covered by the Department of Chemical Engineering. The objective is to train independent researchers at an international level. About 15 PhD candidates graduate from the Department annually.

The research activities are carried out in close collaboration with national and international industry and academic partners. This gives PhD projects on topics of high scientific attention and with a high degree of relevancy for real challenges in industry and society. The PhD programme in chemical engineering at NTNU aims at contributing to the United Nations Sustainable Development Goals by offering course work and research projects where sustainability is at the core of all activities. The PhD programme is intended to comply with current and future needs for competence and skills in chemical engineering in research, development and dissemination at the university, and at other public and private institutions, enterprises and organisations.

The programme includes a wide range of research fields within important national and international chemical engineering subjects. The focus could be on design of new chemical processes, scale-up of processes from lab scale to industrial scale, or on further development and optimisation of existing processes. In other cases, it could be more relevant to develop methods, be it experimental, mathematical or numerical, to be used as tools for characterising, studying and understanding the underlying physical and chemical phenomena which control the various process units.

The PhD programme qualifies for research and development and other activities which require a high degree of scientific perception. The candidate performs an independent research project which leads to a scientific thesis at a high professional level. The candidate should learn critical thinking, dissemination of scientific knowledge and to work in a research team.
The department has excellent laboratory facilities and an extensive international network. The PhD candidates are encouraged to include exchange stays outside NTNU or abroad.

Areas of research

The PhD programme in chemical engineering covers a wide spectre of subject areas and candidates are normally expected to specialize within one of these.

The four main areas of research are:

- Catalysis
- Colloid- and Polymer Chemistry
- Process Systems Engineering
- Environmental Engineering and Reactor Technology

A more detailed description of ongoing research activities can be found at the website of the Department of Chemical Engineering:
http://www.ntnu.edu/chemeng/research

Overall learning outcome of the PhD programme

The PhD programme provides training in generating and publishing new knowledge and understanding. The academic work shall increase the candidates' general competence within their field of specialty.
The PhD research training will be performed in close collaboration with national and international research partners and relevant industry, to educate PhD candidates at a high international level. The programme will strengthen the candidates' general competence and skills within key chemical engineering research areas.

Learning outcome
A candidate with a PhD in chemical engineering should have the following total learning outcome in terms of knowledge, skills and general competence.

Knowledge
After completed a PhD in chemical engineering the candidate is expected to:

- Be an expert in his/her area of chemical engineering specialization and can evaluate the limitations in existing knowledge and methods within the relevant research area
- Master the theoretical basis, problems and methods within his/her research area
- Be able to contribute to new knowledge, methods, interpretations and procedures for documentation and dissemination within the research area
- Be familiar with the risks, ethical and legal aspects related to experimental activity

Knowledge is achieved through:

- The compulsory course work of 30 ECTS credits
- Reading and keeping updated on relevant literature within the field of research
- Laboratory courses and practical training
- The introductory part and summary of the research work of the thesis, where the candidate independently describes the scientific background, and discusses and argue for the choice of approach and research methods, relating the actual work to state-of-the-art in the field and places the academic work into an international perspective

Skills
After completing a PhD in chemical engineering, the candidate is expected to be able to:

- Formulate problems and make adequate plans for research and development in chemical engineering
- Perform and critically evaluate own and others experimental and/or theoretical research work in the field with respect to methods, accuracy, sources of error, good HSE practice
- Carry out research at a high international level
- Handle complex scientific problems and challenge established knowledge and common practice within the area of research

Skills are achieved through:

- Supervision and own research activities
- Preparation and submission of peer-review journal papers, and experience related to the revision and re-submission of reviewed papers
- The thesis dissertation
- Presentation of own research and results at national and international conferences

General competence

After completing a PhD in chemical engineering, the candidate is expected to be able to:

- Identify ethical problems and execute own research with professional integrity and independence
- Perform risk assessment of own research activities and adequately take care of health, safety and environmental aspects
- Be an active partner and handle relevant scientific problems where the candidate works as a part of a research team
- To present and defend own research and results through relevant national and international fora
- To participate in debates within the academic field in national and international for a
- To evaluate innovations and to initiate innovation processes
- To establish a professional network

General competence is achieved through:

- Supervision and own research
- The process of preparing publications and preparing the thesis
- The trial lecture; by acquiring knowledge about a new topic in a short time, time planning, seek/select/evaluate/process and prepare an oral presentation
- Gradually become part of a professional network during the PhD period

Requirements for admission to the PhD programme

Applicants for the PhD programme in chemical engineering must have a relevant master's degree or equivalent education, with a strong academic record.
Applicants are required to have a weighted average grade of B or higher (in accordance with NTNU's grading system) in the two last years of their master's degree (equivalent to 120 ECTS).

Funding

Before you can apply for admission to the PhD programme, the funding of the study period, including running costs, must be confirmed.

Mandatory course work

An important part of the PhD education is the required course work, or academic training. It corresponds to at least one semester of full-time study (30 ECTS credits). The main objective is to provide the candidate with a general and broad theoretical background in chemical engineering as well as giving the candidate the necessary competence and skills required for their actual PhD project.

For applicants with another background than Master in Chemical Engineering it is recommended to include in the course plan some master courses at the department. The faculty offers compulsory training in methods, ethics, HSE and innovation (MN8000 Doing Science: Methods, Ethics and Dissemination).

PhD programme in Materials Science and Engineering

General program description

The PhD program in Materials Science and Engineering provides organized research training in the various research areas covered by the Department of Materials Science and Engineering (DMSE), with the objective to train independent researchers at an international level in close collaboration with national and international research partners.

Research activities in the Department cover, amongst others, ferroic materials and phenomena, materials for energy technology (e.g. photovoltaics, fuel cells, batteries, catalysis), corrosion and coatings, nanomaterials and nanodevices, and physical metallurgy and metallurgical and electro-chemical process engineering with focus on light metals and solar-grade silicon. At present the Department has 44 professors and associate professors, and about 105 research fellows. On average about 15-20 PhD candidates graduate from DMSE annually.

The research activities are carried out in close collaboration with national and international industry and academic partners from DMSE's extensive network. Such collaborations result in PhD projects on topics of state-of-the-art scientific interest and often with a high degree of relevancy for real challenges in industry. Projects often include one extended or several shorter stays outside NTNU. The department has excellent laboratory facilities. The possibilities for funding via national and international funding schemes and industry are good.

The PhD program is intended to comply with current and future needs for competence and skills in material science and engineering in research, development and dissemination at the university, and at other public and private institutions, enterprises and organizations.

The PhD program in Material Science and Engineering qualifies for research and development and other activities which require a high degree of scientific insight. The candidate performs an independent research project which leads to a scientific thesis at a high professional level. The candidate should learn critical thinking, dissemination of scientific knowledge and findings, in addition to teamwork.

Areas of Research

The PhD work gives high level competence within one of the following research areas:

- Metal production and recycling
- Materials development and properties
- Materials for energy technology

A more detailed description of ongoing research activities at the department can be found at the Department of Materials Science and Engineering
http://www.ntnu.edu/ima/research

General learning outcome for the program

The PhD program should give training in the generation and publishing of new knowledge and understanding and increase the candidates' general competence within their field of speciality.

The PhD study in material science and engineering should in close collaboration with national and international research partners and relevant industry, educate PhD candidates at a high international level within the research areas covered by the department, and moreover contribute to strengthen the candidates' general competence and skills within state-of-the-art materials science and engineering. Graduates from the PhD program gain deep insight within their specialization and contribute by large to several of the sustainability goals and concepts put forth by the united nations.

Learning outcome

A candidate with a PhD in materials science and engineering should have the following total learning outcome in terms of knowledge, skills and general competence

Knowledge

After completed a PhD in material science and engineering the candidate is expected to:

- Be in the forefront of his/her area of specialisation and be able to evaluate the limitations in existing knowledge and methods within the relevant research area in materials science and engineering
- Be able to contribute to new knowledge, methods, interpretations and procedures for documentation and dissemination within materials science and engineering
- Be familiar with the risks and legal aspects related to experimental activity
- Mastering the theoretical basis, problems and methods for synthesis and processing of structural, functional and/or nanomaterials
- Mastering the theoretical basis and mathematical models describing the relationships between material structure (e.g. electronic, atomic, nano-/micro-structure) and properties of metals and alloys, ceramics, functional materials or nanomaterials
- Mastering the theoretical basis for relevant experimental and computational methods to characterize and analyze structure and properties of structural, functional and/or nanomaterials

Skills

After completed a PhD in material science and engineering the candidate is expected to:

- Be able to formulate problems and make adequate plans for research and development, on the basis of the current state of knowledge about a certain topic
- Be able to perform and critically evaluate own and other's experimental or theoretical research work with respect to methods, accuracy, sources of error, and good conduct of HSE
- Be able to carry out research at a high international level within their area of research in materials science and engineering
- Be able to handle complex scientific problems and to challenge established knowledge and common praxis within their area of research in materials science and engineering
- Be able to analyse and document own research and results in reports and scientific papers for publication in peer reviewed international scientific journals
- Be able to prepare and present own research and results for presentation at national and international conferences and other fora

- Be able to risk assess own research activities and adequately take care of health, security and environmental issues
- Be able to present own research and results through relevant national and international fora

General competence

After completed a PhD in material science and engineering the candidate is expected to:

- Be able to identify ethical problems and execute own research with professional integrity and independence
- Be able to organise and lead complex interdisciplinary projects
- Be able to be an active partner and handle relevant scientific problems where the candidate works as a part of a research team
- Be able to participate in debates within the field of speciality in national and international fora
- Be able to assess the needs for and to initiate innovation
- Be able to establish a professional network

Requirements for admission to the program, cf. § 5

Applicants for the PhD program in Materials Science and Engineering must have a relevant master's degree or equivalent education, with a strong academic record.

Applicants are required to have a weighted average grade of B or higher (in accordance with NTNU's grading system) in the two last years of their master's degree (equivalent to 120 ECTS).

Funding

Before you can apply for admission to the PhD programme, the funding of the study period, including running costs, must be confirmed.

Course work, cf. § 7.3

An important part of the PhD education is the required course work, or academic training. It corresponds to at least one semester of full time study (30 credits). The main objective is to provide the candidate with a general and broad theoretical background in material science and engineering as well as to give the candidate the necessary competence and skills required for their actual PhD project.

The plan for academic training should be adapted to the research area of the candidates' PhD project and worked out together with main supervisor. The course work should consist of a minimum of 30 credits, of which at least 20 credits are to be taken as established PhD level courses. The new course on research ethics and research methodology is compulsory. Normally a minimum of one PhD/MSc courses (7.5 credits) should be chosen from the courses offered by DMSE. MN8000 "Doing Science: Methods, Ethics and Dissemination" constitutes a compulsory part of the training component.

The NV- faculty offers introductory training in ethics, HSE and innovation through a compulsory one day introduction seminar.

Description of the PhD program in Physics 2020-2021

Description of the academic program

The PhD program in physics aims to educate independent researchers at a high international level in cooperation with national and international research communities, thereby fulfilling both current and future requirements for competence in research, development, and dissemination at universities, other public and private institutions, companies, and organizations.

Subject areas

The physics department covers a broad range of research subjects. We have a particular responsibility for fundamental research, as well as applications of knowledge within the development of industry and society.

Our PhD program provides opportunities for specializations within various fields, including condensed matter physics, physics of porous media, astrophysics, particle physics, quantum field theory, quantum spintronics, numerical physics, optics, energy and environmental physics, and physics of complex systems.

For a more detailed description of research areas, see the department website:

https://www.ntnu.edu/physics

Overall learning goals

The Ph.D. program aims to educate and train candidates with knowledge and skills in physics, enabling the generation of new knowledge to the benefit of society. The Ph.D. candidates will obtain general and field-specific expertise in physics, making them able to contribute to the advancement of the field.

Learning outcome

A candidate who has completed the PhD program in physics should have the following learning outcomes defined in terms of knowledge, skills, and general competence:

Knowledge

The candidate:

- is at the forefront of knowledge within his or her field of physics;
- has a broad physics background, to allow for future flexibility.
- understand and can evaluate the expediency and application of different methods and processes in research and development projects.

The knowledge is gained through:

- *formal training of 30 ECTS credits;*
- *reading and keeping up to date on the literature within the field.*

Skills

The candidate:

- can formulate problems for, plan, and carry out research and scholarly development work;
- can use the research methods of the field to create new knowledge, theories, and methods;
- can carry out research and scholarly research work of a high international standard;
- can handle complex academic issues and challenge established knowledge and practice in the field;

The skills are achieved through:

- *formal training of 30 ECTS credits;*
- *guidance and own research;*
- *preparing publications, submitting them to international journals, and gaining experience with referee reports;*
- *writing the thesis and placing the results in a broader context.*

General competence

The candidate:

- can identify new relevant ethical issues and carry out his or her research with scholarly integrity;
- can assess the risks involved in the work, and safeguard HSE;
- can manage complex interdisciplinary assignments;
- can communicate research and development work through recognized national and international channels;
- can participate in debates in the field in international forums;
- can quickly acquire new knowledge;
- can establish academic networks.

General competence is acquired through:

- *various courses, especially the compulsory course Doing Science: Methods, Ethics and Dissemination;*
- *a basic training in ethics, HSE and innovation;*
- *own research;*
- *working with publications and writing the thesis;*
- *presenting results at national and international meetings and conferences;*
- *giving a trial lecture on an assigned topic.*

Requirements for admission, from § 5 in the regulations

To be admitted to the PhD program, a candidate should have a solid background in physics and other relevant fields. A master in physics or equivalent is required.

Both the previous bachelor studies (equivalent to the first three years of the technology program) and the master studies (equivalent to the final two years of the technology program) should have

been completed with satisfactory results. Normally an average grade of B or better is required for the master degree (or equivalent).

It is further assumed that candidates who are admitted have, in addition to training in basic topics in classical and modern physics, an education that has given experience with both theoretical and experimental physics, and covered key areas such as quantum mechanics, statistical mechanics, and electromagnetic theory. If the previous education did not include such central subjects, the candidate may be required to take additional exams prior to being admitted, or during the doctoral program, preferably during the first three semesters of study. This coursework cannot be included in the formal course requirements of the PhD programme, and examination in such courses must be passed with a grade of C or better.

Finances

Funding for the studies must be available before admission to the PhD program in physics.

Required courses

The course part of the program is equivalent to one full semester of courses (30 ECTS credits). The main goals of this part are to strengthen the candidate's general scientific background in physics, and to give him or her the theoretical background required to perform the work.

Normally, a minimum of 22.5 credits should be within physics or physics-related courses. It is recommended that these courses are chosen such as to provide a diverse overview of topics in physics, thus developing the candidate's flexibility in the field.

The Faculty provides training in ethics, HSE and innovation, through a mandatory introduction program for PhD candidates. In addition, the course MN8000 Doing Science: Methods, Ethics and Dissemination constitutes a compulsory part of the training component.